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THE

MINING INSTITUTE

OF SCOTLAND.

TRANSACTIONS,

Vol. III.

1881-82.

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THE MINING INSTITUTE OF SCOTLAND.

ANNUAL MEETING.

RALPH MOORE, Esq., President, in the Chair.

THE Fourth Annual Meeting was held in the Hall of the Institute, Hamilton, on Thursday, the 14th day of April, 1881.

The Secretary read the minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members:—

A. DOUGLAS BRAND, Coalmaster, 6 Dixon Street, Glasgow.
JAMES BELL, Mining Engineer, Langloan Iron Works, Coatbridge.
THOMAS ORR, Manager, Morningside Colliery, Newmains.
HUGH R. MAKEPEACE, Manager, Bog and Home Farm Collieries, Larkhall.
WILLIAM ALLAN, Assistant Manager, Woodyetts and Dennymill Mines, Denny.

Other nine gentlemen were nominated as Ordinary Members, and will be balloted for at the first meeting.

The Secretary read the following reports :—

THE MINING INSTITUTE OF SCOTLAND—BALANCE SHEET.

Dr. **ABSTRACT OF RECEIPTS.**

1880-81.				
To Balance from last year, ...			... £17	4 9½
„ Members' Subscriptions, 127 @ 21s, ...			... 133	7 0
„ Do. do., 150 @ 10s 6d, ...			... 78	15 0
„ Do. do., 1 @ 10s, ...			... 0	10 0
„ Do. Arrears, 1 @ 10s 6d, ...			... 0	10 6
„ Advertisements, ...			... 21	16 6
„ „ Arrears from 1879-80, ...			... 5	5 0
„ Sale of Transactions, ...			... 7	10 9
„ Interests on Money, ...			... 1	13 8
			£266	13 2½

Cr. **ABSTRACT OF PAYMENTS.**

1880-81.		
By Printing Transactions and Stationery, ...	£108	7 9½
„ Taxes and Gas, ...	... 2	12 4
„ Furnishing and Cleaning Hall, ...	... 3	1 5
„ Rent of Lesser Town Hall, ...	... 0	5 0
„ Stamps, Trains, &c., ...	... 10	15 10
„ Salaries, ...	47	12 0
„ Money in Bank, ...	... 37	7 8
„ Balance in Treasurer's hands, ...	... 56	11 2
	£266	13 2½

8*th April*, 1881.—Examined, compared with vouchers, and found correct.

(Signed), GEORGE A. BISHOP, JAMES BARROWMAN, } Auditors.

LIABILITIES.

Nil.

Balance, ...	£110 15 4

ASSETS.

By Cash in Treasurer's hands, ...	... £56 11 2
„ Money in Bank, ...	... 37 7 8
„ Arrears for Advertisements, ...	... 4 4 0
„ Members Subscriptions in Arrears, ...	... 12 12 6
„ 1480 Copies of Transactions, not valued, ...	
	£110 15 4

8*th April*, 1881, JAMES GILCHRIST, *Secretary.*

The PRESIDENT—I think this is a very favourable report. It is not every society that can show £110 of a balance and no liabilities. I suppose you will agree to pass the report. (Applause.)

COUNCIL'S REPORT.

Your Council in presenting their Report at the end of the third year have great satisfaction in recording the continued progress of the Institute.

The number of Members, as stated in last report, was 209, and is now 297, being an increase for the year of 88. The revenue—including the balance from last year—was £266 13s 2½d, and the expenditure £172 14s 4½d, showing a balance at the credit of the Institute of £93 18s 10d. This sum does not include arrears, which amount to £16 16s 6d.

During the year eleven general meetings were held, ten of them in Hamilton, and one of them in the Waterloo Hotel, Edinburgh. On the occasion of the Edinburgh meeting the Members visited, by invitation, the Niddrie Collieries, and were kindly received by the Company.

The attendance at the General Meetings has gradually increased, and now averages upwards of fifty.

The President opened the session by an able and instructive address, and the following papers read during the year were of considerable interest to the Members of the Institute, as shown by the discussions thereon. They have all been printed and circulated amongst the Members.

"The Detection of Gases in Mines," by Mr Andrew Wilson.
"The Lothian Coal Fields," by Mr Alexander M'Callum.
"Pumping Arrangements," by Mr William P. Barclay.
"A Description of Berryman's Water Heater," by Mr Wright.
"Reid's Patent Safety Cage and Detaching Hook," by Mr Hugh Strain.
"Fife System of Cut Chain Haulage on Inclines," by Mr Robert Andrew.
"Notes on Accidents by Falls of Roof and Sides," by Mr J. T. Robson.
"Description of Bernheim's Portable Fire Annihilator," by Mr John Tennant.
"The South Staffordshire Thick Coal," by Mr Robert Calderwood.
"Screening, with a Description of a Patent Apparatus," by Mr J. S. Dixon.
"A Description of Two Modes of Working Thick Seams of Coal in the Wishaw Coal Field," by Mr Thomas Borland.
"Haulage by Endless Rope and Chains," by Mr Malcolm M'Farlane.

Dr A. K. Irvine, M.D., of Glasgow, brought before the Institute and explained the properties of his ingenious Miner's Safety Lamp, which was highly appreciated.

By invitation of Messrs Robert Addie & Sons, the Institute visited Benhar Collieries, and were afforded an opportunity of seeing Messrs Beaumont & Bicknell's Boring Apparatus at work, driving a stone mine. After being entertained, Mr Bicknell gave an interesting description of his machine.

The Council have arranged with a number of kindred societies of the highest standing, at home and abroad, for an exchange of Transactions. These form a valuable addition to your Library.

The Council, with the consent of the Institute have appointed three of the Members to visit the principal mining districts in England and Wales, to examine into the mode of propping. Their report will appear in next year's Transactions.

The Council have pleasure in reporting that John Watson, Esq., of Earnock, presented a handsome bookcase to the Institute.

The PRESIDENT—I think this very concise, neat report speaks for the progress of the Institute, and, our financial condition being so good, we may congratulate ourselves on it. I would have expected the members to be much above 297; but still it is a considerable increase, and we can hope for more. There can be no difference of opinion as to the benefits derived by those connected with it; and I think all of you must be satisfied that the discussions are becoming more interesting and valuable. I know for myself I have derived a very great deal of benefit from the opinions given out by the members. I venture to urge upon you to speak out your minds freely, and let us have the benefit of your ideas, because there can be no doubt, amongst such a number of practical men, there are many opinions which are of great value and which you confine to yourselves. So that I hope in addition to an increase of members we will continue to have full discussions. (Applause.)

During the evening the scrutineers of the ballot papers (Messrs Bishop & Gemmel) reported that the following gentlemen were elected Office-Bearers for Session 1881-82 :—

President :

RALPH MOORE, Esq., Croft Villa, Rutherglen.

Vice-Presidents :

JOSEPH T. ROBSON, Jesmond Villa, Cambuslang.
JAMES M'CREATH, 95 Bath Street, Glasgow.
JOHN M. RONALDSON, Belton Villa, Pollokshields, Glasgow.
JAMES S. DIXON, 170 Hope Street, Glasgow.

Councillors :

JAMES SMART, Angus Lodge, Hamilton.
JOHN AUSTINE, Oak Lodge, Hamilton.
DAVID ANDERSON, Clydesdale Street, Hamilton.
HENRY TELFER, Overtown and Law Collieries, Wishaw.
JAMES HASTIE, Greenfield Colliery, Hamilton.
JOHN LOVE, Haughhead Colliery, Hamilton.
ARCHIBALD BLYTH, Bent Colliery, Hamilton.
HENRY AITKEN, Darroch, near Falkirk.
JOHN HOGG, North Motherwell Colliery, Motherwell.
JAMES BARROWMAN, Ardenlea, Portland Park, Hamilton.
JOHN GALLOWAY, Barleith and Dollar Collieries, Hurlford, Ayrshire.
HENRY MUNGALL, Cowdenbeath Collieries, Cowdenbeath, Fife.

Ex-Officio Members of Council :

GILBERT BURNS BEGG, Brandon Street, Motherwell.
ALEXANDER SIMPSON, 175 Hope Street, Glasgow.

Treasurer :

MICHAEL ROSS, Clyde Bridge, Hamilton.

Secretary :

JAMES GILCHRIST, Earnock Colliery, Burnbank, Hamilton.

DISCUSSION ON MR BORLAND'S PAPER.

The PRESIDENT—Mr Borland might make any remarks on the discussion that has taken place he thinks fit before we discuss his paper again.

Mr BORLAND—In opening the discussion, I propose to answer the questions as put last meeting night in the order given in the Transactions.

Firstly,—Mr Smart makes reference as to size of pillars. This was a matter I had no control over, the size of pillars and width of openings being stipulated as large areas of pillars had to be left unwrought for surface arrangements. But in working thick seams of coal by the stoop-and-room principle, be the depth from surface little or great, I consider the most economical method is to work only so much of the seam at first working as is necessary for the opening out of the colliery into sections, working out each section as soon as formed by coal cutting machinery; if this is not available, by undercutting in a similar way by manual labour. Next in order is Mr Anderson, in reference to quantity of dross produced from stoops. I may say that 50 per cent. of dross need not be made in working the Main and Pyotshaw together, but in this case it was done, caused, as I said in my paper, by 12 inches of coal being left on for a roof; no parting being there, the coal had all to be hagged down; the stoops being generally surrounded by falls we had not the advantage of an open end, and the coal was often crushed. He next refers to working 12 to 14 yard stoops, as compared with long rances, and thinks as good results could be obtained from the one as the other.

If the working is done by the general principle of allowing the miner to cut and fill the coal himself, there would be little difference as to the quantity of dross from stoops or rances except at the finishing of each stoop when the coal is always crushed, which is saved by rances. The gain in favour of rances in this case is in having a larger proportion of coal produced at a cheaper rate, in having fewer openings, consequently fewer falls to redd, a reduced cost for propwood, and the coal has not the same tendency to be crushed. But the saving in the percentage of dross is derived by undercutting the coal by one set of men and

filling it away by another, and whether it is stoops or rances the same reasoning applies as stated above. I believe it is an established fact that large pillars of coal have been worked in this district by mechanical power in the way suggested and with good results. If this is so, might it not be attempted on a smaller scale by undercutting with men, bearing in mind that the reduced proportion of dross is not obtained by the mere act of the coal being holed by a coal cutter, but on there being a large area holed at one time; whereas with men it is only holed in many cases a few inches and then hagged down, the natural forces never get acting rightly upon it, but undercut it by men nearly as good results may be obtained, considering that 3 inches of coal cut by machinery is useless.

The reason that the rances are formed 24 yds. by 60 or 100 yds., or of whatever convenient length, is that I found four men could hole this length, viz., 24 yards 3½ feet deep, four men could take down, fill, and secure the roof, and have it ready for the holers; and, as will be seen from the plans accompanying my paper, the roads are always in the solid, there is no danger from falls, no brushing or building to contend with. As to working this particular system in any seam, I cannot say, but I understand Mr Anderson has worked the ell coal in this district on a similar principle but by a coal-cutting machine, and what can be done by machinery in coal-cutting can be done on a smaller scale by men. Mr Ronaldson asks a question as to the working of a rib of coal between the exhausted panel and the main road of the adjoining panel. It is worked down hill from the main road of the adjoining panel.

As to ventilation, I observe Mr Hastie makes a statement as to the quantity of air circulating. I also observe Mr Anderson's reply, which is more ably given than I possibly could have done.

I will only say that a large quantity of air is no proof of itself of good ventilation; let the workings if possible be arranged so that the pillars are worked out as soon as formed, a less volume of air will suffice to give greater safety than any quantity of air sent through a colliery where large areas are standing in pillars; a large area of open waste means large accumulations of gas, without

the most careful attention is being continuously given to it; consequently, destructive explosions should they take place.

Reference has been made by Mr Anderson and Mr Ronaldson as to the return airway W W from the goaf. This return airway is necessary if the gases discharged from the strata are to be carried off; otherwise they will overflow into the air currents beside the workmen and be a constant source of danger, while in stooping from the boundary this gas accumulates, the goaf becomes a reservoir for it, and is continually flowing into the air currents. Then as to the meeting of the two currents at W W in the return airway, I may say that the force of an explosion depends entirely on the quantity of gas ignited, and no better proof of this can be advanced than what was said last meeting night by our worthy President, which was to the effect that on one occasion fire-damp had been ignited at a driver's lamp and had been proved by Mr Robson and himself to have run fully a distance of 300 yards. There certainly was an explosive mixture here or the fire could not have travelled, but there was no large accumulation of gas; there was no disastrous results, and is an example of what might be supposed to take place should the current issuing from the goaf be explosive the other currents being non-explosive. But it is not customary to allow naked lights in return air currents supposed to contain explosive compounds. He next says working in panels has a tendency to liberate more gas so far as his judgment goes; no doubt as soon as the roof subsides any gas stored in the strata under pressure will be liberated, which I consider ought to be got rid of at the earliest possible opportunity. When once liberated, there is no danger from it. If kept stored up, the danger is of its bursting into the workings, or escaping, on an open fissure being exposed by the workmen. This early draining of the strata of gas is one of the vital properties of the system advocated.

Another statement of our President is worthy of attention; it is this: That Professor Abel asserts that 2 per cent. of gas in a dry mine is sufficient to carry the effects of an explosion any distance. Apart from the theory of coal dust altogether, I would humbly ask if it is his opinion that should two currents of air such as might be at W W, and the current from adjoining panels, the one from W W being explosive the other containing 2 per

cent. of gas, if this explosive current should by any means become ignited, would the current containing 2 per cent. also become ignited? If so, by what reasoning can it be shown to do so, or where might the proof of this theory be found?

The PRESIDENT—Mr Borland asks the President if there is an explosive current mixing with one containing 2 per cent., will an explosion in the explosive current set fire to the one containing 2 per cent.? Well, that would depend whether the quantity in the explosive current contained as much gas as to make the 2 per cent. explosive also. The general tenor of my remarks was, that when you mix two currents you thereby render that unsafe, inasmuch as the explosion of the explosive current passing into the other one, the effects of the explosion would be felt in both, and therefore, to that extent the system he advocated was inefficient, and I think I went the length of saying that if you want thorough isolation or insulation of each current, you must begin at the downcast shaft and end at the upcast. At the same time, I said that in a dry seam of coal the dust proves a very dangerous element, and I spoke then of what Professor Abel had said about some experiments he had been making. I have to-day had sent me a more extended report of what Mr Abel said at the Seaham Inquest two or three days ago.

The summary of the report, which was read by the coroner, was as follows:—

Comparing the samples of Seaham dust with dusts obtained from other collieries where disastrous explosions have recently occurred, it was found that the most sensitive of the former was somewhat less sensitive than samples of dust obtained from Leycett Colliery (Fair Lady Pit), which ranked highest in this respect among all the samples experimented with. The Leycett dusts corresponded closely with in chemical character and specific gravity the purest Seaham coal dust; their somewhat greater sensitiveness was perhaps ascribable to their remaining more uniformly suspended in air-currents, but possibly also to some physical peculiarities. The result of the experiments with Seaham and other dusts appear to have demonstrated:—

(a.) That coal dust in mines not only much promotes and extends explosions in mines by reason of the rapid inflammability of the finely-divided combustible, and of the readiness with which it becomes and remains suspended in air-currents; but

(b.) That it may also be itself readily brought into operation as a

fiercely-burning agent which will carry flame rapidly as far as its mixture with air extends, and will operate even as an exploding agent, through the medium of a proportion of fire-damp in the air of the mine, the existence of which, in the absence of the dust, would not be attended by any danger.

(c.) That dust in coal mines, quite apart from any inflammability which it may possess, can operate in a distinct manner, as a finely-divided solid determining the ignition of mixtures of only small proportions of fire-damp and air, and consequently in developing explosive effects.

(d.) That a particular dust in a mine (such as the Seaham N dust) may therefore be a source of danger, even though it contains only a small proportion of coal or combustible matter. Although the explosion which may occur through the agency even of a non-combustible powder, in the manner described, may be of very mild or feeble character in the first instance, it may be almost at once increased in magnitude and violence by coal dust which the first ignition will raise and bring into action.

The proportion of fire-damp required to bring dust in a mine into operation as a rapidly burning or explosive agent, even upon a small scale, and with the application of a small source of heat or flame, is below the smallest amount which can be detected in the air of a mine, even by the most experienced observer, with the means at present in use, as has already been demonstrated by the experiments of Mr Galway. Indeed, with dusts of highly sensitive or dangerous character, under those conditions and very possibly with dusts not more so than the least sensitive of the Seaham samples, in the presence of a source of considerable heat and flame, such as a blown-out shot or an overcharged hole would constitute, a small proportion of fire-damp, the possible existence of which in the mine might not be in the least suspected, may serve as the inciting cause to the development of an explosion of coal dust.

In the complete absence of fire-damp, coal-dust exhibits some tendency to become inflamed when passing a very large lamp flame at a high velocity ; if exposed to the action of a large volume of flame, such as produced by the explosion of freely exposed gunpowder or guncotton, it exhibits, in addition, a decided tendency to carry or propagate flame. But, so far as can be determined by experiments on a moderate scale, this tendency (which was exhibited by Seaham X, K, and S dusts, and still more by the more sensitive Leycett dust) is of limited nature, and very different indeed from the property of carrying or propagating flame, which even comparatively non-sensitive dusts possess, in the presence of a very small quantity of fire-damp.

In conclusion, it may be admitted as possible that, with the large volume of flame, and the great disturbing effect, of a blown-out shot, as the initiatory cause of the ignition of dust, and its suspension in the surrounding air, such inflammation may, in the complete absence of fire-damp, be propagated to a greater distance than the results of small experiments would warrant one in assuming. But it can scarcely be maintained that the air

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of a mine in which the coal gives off gas at all, can be at any time free from fire-damp; and as the existence of very small and unsuspected quantities of that gas in the air of a mine may suffice to bring about the ready propagation of flame by coal dust, and thus to develop violent explosive effects, it would appear needless to assume that coal dust may, in the entire absence of fire-damp, give rise to explosions, even of only limited character, in coal mines, in order to account for casualties which cannot be ascribed to the existence of accumulations or sudden outbursts of fire-damp.

The PRESIDENT (continuing)—You see we have a very dangerous element here to contend against in dry mines; and when we consider that Mr Borland—I dare say without intending it—puts forward his paper as a cure for explosions, we cannot—I felt that I ought to point out these conclusions. My opinion was—I have already said—that two per cent. of gas in a dry mine is dangerous to a certain extent, but rendered more highly so by meeting with an explosive current; and to that extent I object to his proposal as a cure for confining an explosion to the districts where it commenced. Therefore, I thought I was justified in saying so, and I believe I am correct. Mr Borland I am sure will give me credit for wishing every young man like him to explain his opinions freely; and I can assure him it was with no wish to carp or find fault unduly that I did so.

As to what Mr Borland has said about taking 100,000 feet of air round an air-course 65 feet area, I think he had not calculated the effect of that. That is 1538 feet a minute or nearly so, which is about 17½ miles an hour.

Mr BORLAND—This was the combined quantity of three currents passing through a short air-way of the above area, tried as an experiment at a most favourable season of the year.

The PRESIDENT—I do not say it is impossible, but I have not seen it. I have seen it in an upcast shaft, but never in an air-course, and I would not recommend any one to try it, because I think it would be attended with very great difficulty, and great disappointment would be felt. Mr Borland talked also of the gas in the goaf. Let us consider what a goaf is. If you have 50 acres of a goaf, it is only the edges that are open and dangerous. The whole space to within 40 or 50 yards from the edge of the goaf is close. I dare say many of you have redd through a goaf and found

it so. Indeed there is no difference between a long-wall goaf and another except in favour of a stoop-and-room goaf, because in long-wall you have the old roads which to some extent stand. It has become a sort of cant expression that a goaf is a large open space—that you may have a hundred acres of an opening the thickness of the seam that has been taken out. That is nonsense.

Mr BORLAND—So far as the remarks of our President are concerned, I think they are very favourable,—in fact, when I asked the question at him it was merely for the sake of obtaining information, and, as I mentioned in my paper, I hoped it would be well discussed so that I might gain information thereby. Therefore, I do not find fault with the President's remarks, but the reverse. As to the goaf, I think it is generally understood that when the roof subsides, except within 40 or 50 yards of the edge, it becomes solid. Therefore, it is only the edge where the gas accumulates. Still, it is known that there is space enough for concealing a large quantity of gas, and with a falling barometer it issues out into the air-currents. Instead of allowing it to accumulate I propose to carry it away as it is given off. In stooping, whether from the boundary of a royalty, or from the boundary of a panel, gas will be liberated. The question is, whether is it better to carry it off by a separate air-way or allow it, as at present, to flow into the air-currents which ventilate the workings, to be diluted thereby. In this case, it is carried off by a separate current. That is the advantage which, in my opinion, it has over the other systems.

The PRESIDENT—I do not see the benefit, because working backwards there would be an open goaf always from the face of the pillars—a goaf behind the workings which could not be ventilated.

Mr BORLAND—That is so in stooping from the boundary.

The PRESIDENT—Well, in a goaf in an ordinary stoop-and-room working, you may have a current sweeping the edge. You, as I understand, propose to bring the gas from the goaf right on to the workings.

Mr BORLAND—I am not sure you quite understand my reasoning. The ventilation of the stoops in the panel is similar to the

ventilation of stoops working from the boundary. But the gas given off in the panel passes through the air-way ww. Whereas in stooping from the boundary the gas escapes into the air current beside the workmen.

Mr SMART—I think at last meeting I said that I considered that stoops of 12 yards are too small. I think Mr Borland, in his remarks, in reference thereto, said they were compelled to work them 12 yards. Of course, we are not compelled to work 12 yards now, and I think we find in practice that 12 yards is too little, and 20 yards is more satisfactory to keep a correct road and safe roof.

Mr HASTIE—I would just like to say one word or two. The question I was meaning to put at last meeting, and which I did not get properly put then, was, looking at Mr Borland's plan, I was anxious to see how much air was going through those roads? It was for that information I looked up the Government returns, as I wanted to ascertain how much air was in the panels altogether. I would like to ask, assuming the existence of gas in those panels, how much air would be required to keep them safe?

Mr BORLAND—Mr Hastie's question is rather a difficult one to answer, because you would require to know what quantity of gas was coming off. Taking each roadway, the area through which the main current is taken would be 8 feet wide by a height of 7 feet. That would be 56 feet, but take it at 6 feet high, I do not know of a greater velocity being needed than 5 feet per second —that is about 15,000 feet a minute in each current.

The PRESIDENT—That would alter the quantity of air you require. If you had four panels stooping you require more air?

Mr BORLAND—If you had four panels stooping, you would require four currents of air, and with four in formation other four. Eight times 15,000 is 120,000.

Mr ANDERSON—I think Mr Borland is just being hurried enough. I think we should give him a little more time. The plan shewn here is perhaps not so very bad after all if there is not too much claimed for it. I do not think it is a perfect cure for explosions, but I think I would be prepared to agree with what Mr Borland said there just now, viz., he only requires to have eight currents, even suppose he is taking out stoops in four

different panels. Of course he would not go on opening up the rest. He would take out the two panels going level course, one at the bottom and the other up here (shewing); and the same on the other side. These four panels are in operation, taking out the coal inside the panel in the stoops. Then there are two new panels opening out on each side. By the time these new cuttings are formed, the first panels are wrought out, and they commence to take out the stoops in this second set, and also begin cutting out anew for a third set. He has only four places opened out, and the four panels taking out stoops. So that, if he can get 100 tons out of each of the panels, there are 400 tons from the stoops and a fifth out of the solid. That produces nearly 500 tons a-day. From the demands on the ventilation, it is quite likely, in the opening out of the place where the fifth of the coal is being produced, he may possibly do with a less current there, although it is opening out and a place which, in general, should be well ventilated. There will not be so many men in it; and the air will be easily confined to the face, as there are very few openings. That would leave a larger quantity of air for the ventilation of the inside of the panel. What I understand Mr Hastie's question is, how much air he would pass into the inside of the panel after the whole of the coal is taken out?

Mr HASTIE—I meant, if that was a fiery section, in opening up those panels, how much air would be required to keep it safe?

Mr ANDERSON—Well, while they are opening out in the solid, they are taking out these stoops. Mr Smart stated there was scarcely so much gas given off when the roof begins to come down. If that is the case, the remark that I have made, that a less quantity of air is required in the solid, is a mistake, because, where there is least gas given off, the greatest current would be. I suppose Mr Borland would incline to confine his output to four panels taking out the stoops and four panels opening out. As to the escape of the gas through this opening at W W, I do not think he has thrown any light on that, which gives us the idea that it would not communicate and carry on the explosion from one current to another. I think, were that still to remain, it would be a very great source of danger.

The PRESIDENT—The point which I want to bring out is: we

have here a plan before us in which there are so many currents of air shewn, and it is very evident that the plan has been made out without the expectation that we would discuss it as closely as we have done.

Mr ALEXANDER RITCHIE—Mr Borland in his paper makes a statement with reference to taking out the whole coal that is in the field, would he explain how he intends to take out the 8-yard rib that he leaves in between the panels? From my experience of stooping these 15 years, I think where there is too much coal left in stoops there is always a loss of coal and wood; and from the experience I have got I have always noticed that there comes to be more dross in it. It appears that Mr Borland has been paying fathomage here; is there nothing allowed for side cutting? As far as I can understand, in that colliery there is a regular tonnage, and 3s per fathom extra.

Mr BORLAND—As to the remarks about 8 yards of coal, I presume it is that between the main road of the second panel and the exhausted panel, which is 14 yards, not 8 yards. The same question was asked by Mr Ronaldson at last meeting, and my reply is that it was worked down hill from that road (shewing). Mr Ritchie has also remarked about the side cutting. I said, I think, in my paper, that the coal was undercut by miners at so much per square yard, and that as they had to shear or side cut the coal when working as shown in Plate XVIII., they were allowed two square yards for side cutting. The lifts or cuttings were 16 yards long, and 2 yards were allowed for side cutting, the reason being that if the coal was not shorn it would not come down so easily. Therefore, the first thing the men did was to shear it. As to 3s being paid for fathomage, that is a mistake. They were paid by the ton and no fathomage; in narrow places fathomage at the rate of 1s per yard, equal to 3d per ton extra for driving narrow. The fillers had for filling 5d per ton, when wages are as at present.

Mr Ross—Would Mr Borland say how many of those panels he extracted contiguous or lying near to one another,—how many of the panels he extracted full out? And with reference to the strip of coal mentioned, I see between the panels immediately adjoining the strip of coal there are small pillars: was his percentage of

dross in that strip of coal and the small pillars adjoining not greater than in regular stooping?

The PRESIDENT—Mr Borland said there was a porportion of coal left in the roof, and that, I anticipate, he calculated as dross: is that so?

Mr BORLAND—No. In the first formation of the panels, I think there were about five panels adjoining one another all in a line. They were worked on the same principle as shewn in the plan, from the head of the incline inward, and what was left were two rances of coal as shewn in the level road. That had to be worked back from the boundary, and was undercut in the same way, and was the cheapest coal produced, because we lost no wood from it. Speaking to the plan, Mr Borland went on to point out what the tendency would be if the coal to the right hand were all worked out. You would only have 26 yards of coal there if the panels were all worked down to the boundary, but in working it down, you must take this 14 yard rance and 12 yard stoops, and perhaps 12 yards of this rance adjoining here (shewing) along with you, which forms a sufficient support for the roof and prevents the pillars being crushed. I may say, in one case, where two rows of 12 yard stoops were left in the waste, we found them to be very much crushed when working them—in fact, there were 50 per cent. of it crushed, and we had to guard against that.

Mr HOGG—I would like to ask if he really got out the rances of coal referred to on plate XVIII. at W W? At C there is a small square pillar; suppose that pillar taken out and the wood drawn, how does Mr Borland catch the rance of coal to work it out. I have seen a difficulty with that, and would like to know how he overcame it.

Mr BORLAND—The reference made is to the rance of coal between the underside of the second level road, and the exhausted panel below it, and Mr Hogg wants to know how this rance of coal can be worked back if the small pillar at C is worked out and the wood withdrawn. The answer to that is, that after this second panel here (shewing) has been exhausted, you have three rances of coal—that is two above the level road and one from it to the exhausted panel—and to get these worked out, we run a road from this heading (shewing) about six feet from the exhausted panel, and that works the coal back to the solid road.

Mr HOGG—May I ask how Mr Borland ventilates the place, when it is waste below and waste above?

Mr BORLAND—The gentleman misunderstands that before you stoop out these two rances above the level road, this under road is driven, and that is ventilated in the usual fashion. Then to work it back, you have the three rances to work back.

Mr HOGG—But you stated you worked it downwards. You work it upwards?

Mr BORLAND—That was the rib of coal referred to by Mr Ronaldson that I said I worked down hill, which is different from the one now referred to.

Mr RITCHIE—I quite agree with that 70 yards rance of Mr Borland, because it has the Wishaw rock for a roof, but where the roof is fire-clay, and taking out so much of the rance, I am of opinion that the roof would break over the props, and then he would require to open out the face anew; but with the Wishaw rock for a roof he would have no difficulty in extracting all the coal in the rance.

Mr BORLAND—That is the reverse of what we find. I am speaking of what was actually done. I mentioned previously that as long as the roof was fire-clay we could easily work, letting the roof fall behind us, but where there was twenty feet of rock we found it impossible to break off the rock with props. In twelve feet we could always work and draw the wood. When the fire-clay was above the coal, the roof got hard and we could not do it.

Mr RITCHIE—I have stooped in the pit marching with Mr Borland's in the main, splint, and ell coal, and we could always take out more coal where we had a rock roof.

Mr BORLAND—I think what Mr Ritchie says and what I say is the same, although there is a slight misunderstanding. With a soft roof we found it very difficult to work out 12 yard stoops; but, formed into rances, we had no trouble unless it stood for a day or two. If it did the weight came over and broke the fire-clay; but if the rances were kept going on, we had no trouble with that, and we could drop the roof every third day.

The PRESIDENT—Explain the relations of the men holing and filling in the morning.

Mr BORLAND—We will take the instance of a new rance being commenced. The men at night start to undercut that rance of coal. They go down at eight o'clock, and they undercut a distance of six square yards, each man 3½ feet in. The reason for that is, the coal never breaks to the backside, and we require to cut 3½ feet to get 3 feet. These men were generally finished when the fireman went round at five o'clock in the morning. The fillers go down at six. The coal is all gibbed up, and they take it down as they go along. They were quite able before five at night to take down and fill 24 yards of the rance. That is to say, four men filled the coal and secured the roof. There were four men holing and four men filling—that was eight men in all—and the quantity produced was fully 48 tons.

The PRESIDENT—If it took 10½d, 5½d was for holing and 5d for filling.

Mr BORLAND—Rather more than 5d for holing, but that was about an average—10½d per ton. You do not require to pay so heavily for filling. For holing and gibbing up the coal, you require the best men you could get. Men worked both night and day, something the same as a coal cutting machine.

Mr GILCHRIST—There is one point in Mr Borland's remarks to which I wish to direct attention. I think he said that a large area of open waste meant large accumulations of fire-damp. I cannot say I have had great experience, but so far as my experience goes, I never found this to be the case, and I would like very well if some of the older members that have had more experience would take up this point.

Mr ANDERSON—I would like to know what it cost per square yard for the holing? We have it that a man holes six yards per night, and we have had the coal given at six feet eight inches high. That would need a good price per yard to pay a first-class collier for holing six yards per night. I have no doubt at all but it can be done, and I do not think that any one who has not tried it is in a position to say Mr Borland is wrong. He made one remark in regard to the work being carried on regularly. The men are holing at night, and the others are filling during the day. I see a gentleman here to-night who said he was going to make an experiment. I will neither name him nor look at him, but if he

has done so, I will be glad to hear the result of his experiment in that direction. Both he and I agreed it was possible it could be done. I think the whole thing depends on being regularly worked. That is the great drawback of even coal cutters. If you have not regular work—if the face is not carried forward every day—it is a complete failure. I think the same remark will apply to the system Mr Borland advocates. If the system is carried on regularly every day, there cannot be any difference in the cutting by machinery and a miner's labour. There may be a little more dross, but that can be the only difference. Then, that matter about the eight yards pillar; I am like some of the others, I do not see daylight through it. The questions asked about it have not elicited any mode of taking it out which would be practicable. I would like to hear a further explanation about the system of taking it out.

Mr BORLAND—As to the last remark by Mr Anderson, I will prepare a small sketch before next meeting, to show how the pillar referred to can be worked out. (Plate I.) The first question as to cost per ton per square yard of holing it was 10d per yard when wages are as at present.

The PRESIDENT—I think this discussion is so interesting, we will adjourn it to another night. The President afterwards referred to a German system for cleaning dirt out of dross by means of a current of air, and promised a description for next meeting.

DISCUSSION ON MR M'FARLANE'S PAPER.

The PRESIDENT, in introducing the discussion on Mr M'Farlane's paper, mentioned that Mr Austine had very kindly asked him to say that he would be very glad that the members should see the haulage system at Cadzow and Allanton.

Mr M'FARLANE handed to the Secretary a plan of the surface arrangements at Allanton Colliery, and explained it as follow:—The rope after leaving the engine-house passes round a 3-ft. pulley

(No. 1 on plate), then round another pulley fixed on the "Stenting" carriage No. 2, from which it goes direct to No. 3, for the purpose of removing the loaded waggons to the weighing machine. At this point it lifts nine loaded waggons at once. After being weighed the waggons are drawn into the siding at No. 4, a distance of 374 yards. The rope then descends the embankment to No. 5, where it is used for the purpose of drawing the empty waggons to No. 6, a distance of 390 yards. The trains at this point are composed of six empty waggons. The rope then returns to No. 7, taking the loaded waggons from No. 2 Pit to the weighing machine, and from this to the sidings at No. 7. The dross made at No. 2 Pit is drawn from the weighing machine to No. 8, thence by incline to No. 9, a distance of 462 feet, rising 1 in 8.

Mr GILCHRIST—I would like to draw Mr M'Farlane's attention to p. 259, where, speaking of the haulage on the surface, he says, "The rope is $\frac{3}{4}$-inch diameter and 1500 yards long." Then, in calculating the work done, he only allows 260 lbs. for the weight of the pulleys and rollers. Are both statements correct? If not, which of them is wrong? Again, has he not considerably underestimated the cost of the material used, even although it was old? I understand that the rope he refers to was a new one when he started this system; if I am correct, it would cost at least double the price that he has entered against it.

The PRESIDENT suggested that Mr M'Farlane should reserve his reply; and the hour for adjournment having arrived, the meeting separated.

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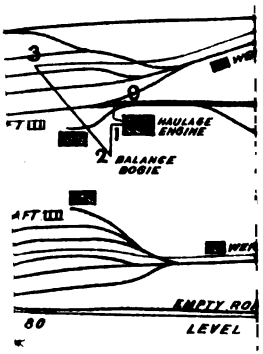


THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 12th MAY, 1881.

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

RALPH MOORE, Esq., President in the Chair.

THE Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members:—

HENRY S. MUNROE, School of Mines, Columbia College, New York.
JAMES W. TORRANCE, Wood Merchant, 69 Buchanan Street, Glasgow.
JAMES DICK, Inspector of Wishaw Collieries, Knownoble, Wishaw.
JAMES PAUL, Manager, Law Colliery, Carluke.
DAVID ROBERTSON, Manager, Dalquharran Colliery, Maybole.
ROBERT CUTHBERTSON, Manager, Bargennie Colliery, Maybole.
JAMES GRAY, Manager, Linridge Colliery, Newarthill.
JAMES PRENTICE, Manager, Brownyside Colliery, Airdrie.
DAVEY THOMAS, Manager, Cowdenbeath, Fife.

Other ten gentlemen were then nominated as Ordinary Members, and will be balloted for at the first Meeting.

Mr MOORE made the following remarks :—

I need not repeat what your Council said at last meeting as to the valuable papers and the discussions which have been published by this Institute further than to remark that they will stand comparison with those of kindred institutions in the kingdom. Nor need I say a word as to the finances. It does not appear to me that this Institute will ever fail for lack of funds; still I should like to see a great number, more coal owners amongst us, not merely for the sake of their subscriptions, but as shewing the interest they take in the advancement of improved modes of mining, and in our efforts to improve it. I have said on a former occasion, the owners of mineral property are the parties who mainly benefit by the deliberations of a body like ours, and I would recommend that the Council should issue a short circular on the subject urging that every coal owner in Scotland should be a member. I am sure, that even in these dull times, none of them will miss the yearly subscription of one guinea.

Although, I think, there is no need for anxiety about funds, there is always anxiety for papers of the right sort, and I trust that the members will see to the keeping the quantity and quality of these up to the highest standard. Might I indicate that papers should be short and well illustrated and detailed. Many of you may be deterred from contributing by the seeming difficulty of being unable to make a long paper. You will probably find the greatest difficulty will be to make it short. A paper need not occupy half-an-hour's reading, it need not occupy ten minutes.

It would be exceedingly useful to have more details of pit-work in our Transactions—say, for example, the mode of setting pipes and beams in a shaft, good details of pump rods, buckets, clacks, plungers, and such like. Mr Dixon's paper on winding is a good example of detail. In the same way pithead arrangements, screens, plans of pit-bottom, hutches, are all suitable subjects; in short, anything good and well tried or out of the common which occurs in our daily practice might profitably be made known and discussed. Gentlemen must always bear in mind that in thus imparting information to the Institute they are also educating themselves. I feel that I cannot exaggerate the importance of

this, especially to the younger members, who are to be our future colliery managers, and I trust the future coal owners of their day. Improvements come so thick upon us that we need more than ever to be on the alert to keep pace with them. I pray you look back to the state of mining in Scotland only twenty years ago and compare it with its present state. Was there one of us in his wildest dreams who ever contemplated spending £1000 on a furnace? and yet I have now in my mind's eye a place in this county where more than £3000 is being spent on appliances for producing ventilation, and all of you know that large sums are now considered absolutely necessary.

Was there one of us contemplated haulage on level roads, such as we now see in use? I believe there were one or two instances of tail ropes, and in many cases the orthodox dook engine, but look now at the many miles which we now have.

A fewer number can personally talk of the state of matters forty years ago; but I can tell you that at that date there was not more than one pit in Lanarkshire—I think there was one at Carnbroe—that had slides and cages in it. I recollect of making a drawing of slides and cages in the Summerlee Offices forty years ago, at which time that Company had not one in operation. I don't think there were twenty wire ropes in Scotland; look at the number now!

I recollect that a pump was erected in 1838 in the bottom of Prestongrange Pit to raise water 70 fathoms in one perpendicular lift. The precautions to make good joints and good clacks were something wonderful, whereas 160 fathoms of an upright lift is nothing wonderful.

I might take up your time all night, and more, in drawing such comparisons, but it is only a record of progress. The young men among us when they are able to tell their experience of forty years will tell the same story.

I am glad to learn the electric light is to be fitted up at Earnock Colliery, which will give us an opportunity of studying this important invention. I think this light is fast getting beyond the region of experiment. It has lighted some of the streets in London for more than twelve months. It may be years before it will be applied to the lighting of the working faces of mines,

but that it will be so applied I have not the slightest doubt. In the meantime, lights on the surface, shaft bottoms, main roads, and any particular points may all be lighted with it.

I am glad the Institute continues to send Commissioners from their members to other districts when it is considered necessary. I have had the privilege of seeing some of the notes of the last commission to enquire into the modes of securing the roofs and sides of mines. They were underground in twenty mines in England and Wales and will be able to give a good deal of information on these points. It is notable that they were received with the greatest kindness, and every information was tendered them.

I do not know that I should detain the meeting further, but may be allowed to mention one point. It will always happen that only a small proportion of our members can be present at our monthly meetings, and as it is desirable that those who cannot attend should send their remarks upon the papers, perhaps it would be well that the discussion on all papers should not be closed until the papers have been a month in their hands.

Another point occurs to me as being worthy of the notice of your Council. You are aware that the Institute exchanges papers with many other kindred institutions and these papers are available for such of the members as are able to come here to read them. But I think if a small committee were appointed to examine these periodicals monthly and write a condensed account of any thing in them which would be interesting to the members to know, it would greatly enhance their value to us. These abstracts should be published monthly, and take up say two or three pages in each month's papers. I am satisfied there are many young gentlemen among us willing to undertake this duty. In this way the latest information would be disseminated among all our members, and any one wishing further information could come to the Library and read the whole paper, or purchase the paper for themselves. I have nothing further to add at this time, but to ask that each individual member should endeavour to secure new and especially working members for us. We do not despise money, and, as I said before, the Institute will not die for the want of funds; we do, however, want

additional working members, and I trust that at the next annual meeting the members instead of standing at three hundred will not be under one thousand.

Gentlemen, I don't think I should sit down without asking you to award a hearty vote of thanks to the Council for the time and ability they have devoted to our interests. I question much if any society has flourished more than we have done for the short time we have been in existence, and I feel that very much is due their tact and industry in conducting matters.

MR BORLAND'S PAPER.

The PRESIDENT—The first business to-night is the discussion of Mr Borland's paper.

Mr BORLAND—I have nothing to add to what was said last night; only I might ask Mr Anderson a question. He asked at last meeting the price per square yard for holing by men. I would like to know the price per square yard for holing by machinery?

The PRESIDENT—Are you prepared, Mr Anderson, to give any figures?

Mr ANDERSON—I can give them roughly. Three men cut 150 yards in a night.

Mr BORLAND—I meant to include expenses, such as repairs and up-keep.

The PRESIDENT—I think that is scarcely a matter before us just now. It is the discussion of your paper.

Mr SMART—I think that was all discussed before very minutely in connection with Mr Begg's paper on "Coal Cutting by Machinery."

Mr ANDERSON—There will be no harm in mentioning incidentally, that Mr Hurd, who had a Coal Cutter, offered to do the work at 1d a ton, and ¼d a yard for cutting along the face.

Mr H. TELFER—At page 228, Vol. II., Mr Borland says that the stooped coal in panels will be as good in quality as coal worked from

the solid, while, at he same time, the dross produced will be considerably less. Although that may have been the case in the seam worked by Mr Borland, I am of opinion that in any thick-seam where the coal is only moderately hard, with a tolerably hard roof and pavement, you will hardly ever get the coal as good, and the percentage of dross will be higher in taking out the stoops than in working the solid, whether it be worked panel system or ordinary stoop-and-room. What I have found to be important in the working out of stoops, and what tends to reduce the percentage of dross, is to keep the section of stoops that is being worked out in as straight a face as possible, never allowing a stoop to be projecting into the waste, or it will be sure to be crushed. In the discussion at page 242, Vol. II., Mr Borland, in reply to Mr Dixon, says he has no doubt if the Ell Coal was undercut 3½ feet deep, you would reduce the dross considerably. I can tell Mr Borland that in working out Ell Coal stoops in a pit of considerably less depth than those in Hamilton, where we tried to enforce deep undercutting, the pressure on the face usually burst the coal off before half that depth was reached. It was suggested by the President that Mr Borland might visit some of the pits in Hamilton and see the system of working adopted in them. If he has done so, it would be interesting to hear from him whether he thinks his panel systems, as shown on Plates XVI., XVII., and XVIII., Vol. II., are preferable to the systems he saw being practiced in the Hamilton district. Then, at page 237, under the third head of this paper—the securing of good ventilation—Mr Borland says:—"By referring to Plates XVII. and XVIII., Vol. II., it will be observed that each division is ventilated by a separate current, returned direct to the up-cast." I think it is very objectionable that these currents join each other in some cases long before reaching the up-cast; they should have a distinct air-way to return in as nearly as possible to the bottom of the up-cast shaft. And again he says, "There is a return air-way at WW for carrying off any gas discharged from the roof when subsiding." In working a seam of coal such as Mr Borland described, when the roof consisted of 8 feet fire-clay, the opening at WW would most likely be closed up whenever the first stoop opposite it was

taken out, and in that case would do little good or harm. It might be very different if the roof was of a strong nature; this opening at WW remaining even partially open might prove a source of danger. Supposing a fall of roof to take place in the air-way beyond WW, the return air from the winning-out panel above would be forced through W W into the pillar workings. In his concluding remarks Mr Borland says, "Should an explosion take place it could not possibly communicate to a second division." That is a very strong assertion to make. I fail to see what would prevent the communication, and I fully agree with Mr Anderson's remarks on this point. If it was really a fiery mine that this system of panel-working and splitting the air was done in, I, for my part, would not like to be in any panel if an explosion should happen in another.

Mr BORLAND—I think the first part of Mr Telfer's remarks is as to visiting one of the Hamilton pits. Well, I visited one of the pits in Hamilton and saw the system of stooping, which was similar to that adopted in every colliery. Whether it would be better to work it in panels or the system that is presently adopted, I cannot say, because the coal, so far as I saw, appeared to be so friable that it would not stand to be holed. Whether this was owing to the friable nature of the coal or the weight that was crushing it, I do not know. I understand the workings in the solid stand very well; if the working places were driven narrower, having fewer openings, and formed into rances that crushing might to a certain extent be saved. Of course that is a point I would not like to be definite on, for it would have to be tried; but I have no doubt it could be worked in rances instead of in steops. The proportion of round coal would not be so great as in working the main and pyotshaw seams together, for the ell seam in this district is more friable. If it was formed into rances (with eight feet opening between them) by 24 yards broad, and could work these rances back on the plain of the coal, breaking the roof off with trees, say every third day (a method similar to that shown in Plate XVII., Vol. II.), although it might not stand to be undercut, the proportion of round coal would be better; but if it could be undercut, a considerable saving would be effected. As to Mr Telfer's remarks about the return air-way

WW, when the roof falls, he seems to think it would be filled up. There is no doubt the roof will fall above the top of the air-way, still there would be space left for the gas to escape for a considerable time before the waste became solid. The great thing in this return air-way is to carry off the gas as it is made, not to allow it to accumulate. If the workings are so conducted that there is no space for gas to accumulate, and some means taken to carry off the gas discharged in the waste, the force of an explosion would not be so great as imagined by some of the members.

Mr DRINNAN—I did not hear Mr Borland read his paper, but after reading it, my sympathies were strongly enlisted on behalf of the colliery managers in and around Hamilton, thinking they would be likely to have a very hot time of it with their employers after Mr Borland had so clearly demonstrated that almost all the dross made in working coal, and all the explosions that had caused such a destructive loss of life were due not to unavoidable causes but to the incompetency of the managers. I was, however, prevented from attending the meeting when the paper was discussed; and now, after reading the discussions, I must say my sympathies are all on the other side. I am inclined to go further than Mr Anderson in saying that Mr Borland was much hurried, —I would be inclined to say he had been very much worried. Certainly, I have no inclination now to worry him any further, But I think even Mr Borland will be prepared to admit that, however good his system is for working the coals in his district, he cannot but be aware that there are very many coals to which the system would not be applicable at all. One of the great advantages which he claims for it is the division of labour. The holing is done by one party and the taking down and filling by another. Now, there are very many fields, by reason of the nature of the coal itself, by reason of the nature of the strata above, which it is impossible to work according to the system he advocates. There are many such coals. Indeed some of the thick seams he makes special reference to, it is not possible to hole them; it is only by a system of "hagging" they can be worked.

Mr BORLAND—Before concluding the discussion, I would make a reply to the gentleman who has just spoken. In bringing the

system forward, it was not with the pretence of setting forth a system that would be applicable to every seam of coal, because I knew there were many seams of coal that could not be worked on the system advocated. The object for bringing it forward was to show what might be done in a thick seam of coal with a soft roof —or rather, what was done, because it is well known to most of the members present that in a colliery where the roof is soft and liable to falls, many of the pillars are buried in the falls and become lost; and there is no doubt there are large areas of coal that will never be got on account of their soft roof and not having been worked after the pillars are formed. I think Mr Drinnan will admit that; whereas, if they were worked immediately after the pillars were formed, or formed into large rances, they will be saved altogether. It would not only be a saving to the employer and the landlord but a national gain if that were done. I know in the Hamilton field, the roof is not soft: they have no fear of that here, and the system of working in rances and breaking the roof off with trees would not be applicable at all, because the trees would not break the roof off.

The PRESIDENT—That is done regularly,—the roof broken off with trees.

Mr BORLAND—I understood from what I saw in Hamilton and from enquiries otherwise, it could not be done. If it is done, the system of working the rances is applicable to working the ell coal in Hamilton, but that is the difficulty. In working as shewn in Plate XVII., Vol. II., it was quite easy working and breaking the roof off with trees, because the roof was soft; but I mention in the paper that as the working advanced towards the southern boundary, the roof got hard and could not be broken off, and the system had to be given up. The system adopted in Plate XVIII. was tried where the roof was hard and worked perfectly well. Where, however, the roof can be broken off with trees, I have no doubt the system of panel working is applicable. In bringing this discussion to a close, I cannot but tender my thanks to the gentlemen who have taken part in the discussion, also to several others who have given me private assurance of their concurrence with several points set forth in the paper. Although the method of working suggested may not meet with the entire approval of the

members, it being a mere outline of a series of experiments extending over several years; nevertheless, there may be some points in it worthy of notice that might be taken up and experimented upon by some one; if so, I would only be too glad to give any further information I might possess. In reviewing the discussion, I believe I set forth at the beginning that an explosion taking place in one panel, it might be confined to that panel. Now, the force of an explosion depends entirely on the quantity of gas exploded, and in support of this I may be allowed to quote the words of an eminent author (Mr Warington W. Smith, M.A., F.R.S.), where he says:—"According to the abundance of gas, the form of the excavations, and the efficiency of the ventilation, explosions may be either quite harmless or may injure only one man or a few men in a single locality, or in the worst cases may flash forth with such lightning speed and fury as to leave not a man alive. Such being the case it behoves us to try and find out what is the best system of working as to safety of ventilation and economy of working, and at the same time a system whereby the whole coal may be nearly extracted in its best marketable state." It is known that many scientific plans and chemical processes have been suggested, having for their object the rendering harmless noxious gases met with in mines. But as yet it may be safely affirmed that the only true way of doing this, is to have the colliery divided into sections, ventilated by separate currents of air, having a slow velocity, large area of airways, with short distances to travel, having few openings in the solid so that the currents of air may sweep into every corner, and at the same time some means for carrying off the gases discharged on the roof, first subsiding, thereby causing it impossible for gases to accumulate. Should an explosion then take place, I may be allowed to say it would be harmless and not extend to adjoining panels. As to the working of coal, whether the present system of working thick seams of coal will hold good against the introduction of machinery, time alone will prove, but one thing is certain that there are many cases where mechanical power could not be economically adopted; but might there not be an attempt made on a small scale by manual labour similar to that adopted with coal cutters, seeing that such great advantages are gained by the use of these machines,

and more especially where the roof is of a soft nature? Whether any of the above conditions may be gained by the system advocated I believe it may best be left for each individual member to judge.

The PRESIDENT—I do not think there is anything new in the modes of working; neither do I think that they will succeed in all cases. The rance is neither more nore less than a large stoop. I call it stoop-and-room or room-and-rance, although every stoop is 200 yards square. Long-wall is a long-wall; it may be a mile in length, but room-and-rance is simply large pillars which may be useful in one part and not in another. There is nothing whatever in Mr Borland's mode of ventilation that is very wonderful. I suppose he had not seen the Hamilton stoops before he wrote his paper, and had he seen them perhaps he would not have spoken so strongly. I ask you to second me when I propose a hearty vote of thanks to Mr Borland for his paper. (Applause.)

MR M'FARLANE'S PAPER.

The PRESIDENT—The next thing is to discuss Mr M'Farlane's paper on "Haulage by Endless Rope and Chain."

Mr TELFER—I would like to ask if the $1\frac{1}{8}$ inch rope referred to at page 261, Vol. II., is an iron or steel rope, and whether it is made in the ordinary way?

Mr M'FARLANE—The first rope put on was a Bessemer steel rope made in the usual way, but we have also adopted a common winding rope which does quite as well if not better. With reference to the question asked by Mr Gilchrist, where he makes reference to the diameter and length of rope and the weight of the pulleys and rollers, the weight of pulleys has been omitted in my paper. There is only the weight of the rollers given, but the friction is given at 1-20th of the weight.

Mr GILCHRIST—Should the weight of the pulleys not have been given, or is it a mistake?

Mr M'FARLANE—That has been omitted, but, as I have said, you can take into account the friction. Then, Mr Gilchrist says I have not estimated aright the cost of the material even although it was old. I do not know whether I have done so or not, but after material is thrown past, useless for pit working, it is generally estimated at half price.

Mr DIXON—Following up what Mr Telfer has said, I understand that in the haulage described the driving strap goes down the shaft, and that the strap in the first instance worked in a figure eight on ordinary groved pulleys. I would like to ask what advantage was obtained by the adoption of the Thorncliffe pulley in the life of the rope? I may say that I have had considerable experience of this system of driving, and I am not altogether satisfied with it. Mr M'Farlane has told us he put on old winding ropes. I would ask how long they worked? because we tried such, and they worked only a few weeks, and did not pay the cost of putting them on. We have tried iron, Bessemer steel, plough steel, and a special quality of plough-steel ropes; and I may say for endless rope haulage, I have come to the conclusion, the very best rope that can be made is the cheapest in the end, because a great source of expense is in putting the ropes down. Changing a rope like that in a hundred fathom pit is no joke.

Mr M'FARLANE—We came to believe that the constant rubbing on the pulleys was injurious to the rope, and that was the way it was abandoned; but, beyond that, with the figure eight, when the full loads were put on the different branches, the rope slipped on the groved pulleys, and after the Thorncliffe pulley was put on there was no such slipping. As to the wear of the ropes, I saw old winding ropes put on, but did not see them worn out. It was doing well,—better, in my opinion, than the steel wire rope, because the steel rope requires a pulley of large diameter,—a pulley larger than the common wire rope.

Mr DIXON—Can you compare the two, the Thorncliffe pulley with the others exactly as to last of rope?

The PRESIDENT—I was going to ask if Mr Austine, who really introduced the Thorncliffe pulley into the district, would kindly give us some facts about it?

Mr AUSTINE—I did not come at all prepared to go into any discussion to-night. I have seen Mr M'Farlane's paper, and I find in looking over it that if I were to go into the matter, to make any remarks it would be really to investigate the whole thing, and I am not prepared to do that. As regards the Thorncliffe pulley, in going through some pits in England before we introduced the haulage into Cadzow, I came across this pulley at Thorncliffe. I saw it working, and made enquiry, and found the ropes ran three or four years; I thought it was the thing for me, for I found that we did not get our ropes to run many months. It was resolved to adopt this system for Cadzow. We had, however, a great deal of work to do before getting ready for it, and in the meantime got the pulleys made by Mr Grant, of Kilmarnock, and got them fitted on at Allanton. There we had the two pulleys with six groves, and we found on many occasions when loaded, the pulleys went round without the rope, notwithstanding the figure eight, under the old system. After the Thorncliffe pulley was put on nothing of that sort occurred. I think it would draw everything out of the pit before giving way, and so far as I have been able to see, it does no harm to the rope. The first rope at Allanton on this pulley was Bessemer steel, but the maker did not understand, or did not think what was most suitable, for he made the wires very thick, and the result was the rope gave way in three or four months. Mr M'Farlane told me it was giving way, and I ordered a new one, but before the new one was got the other had gone to pieces. As an experiment, and because I could not wait for the new rope, I took two of Peter Haggie's old winding ropes that had drawn 500 tons daily for two years and had been thrown aside, not because there were any broken wires, but because I thought they had gone long enough. I had them spliced and put on the haulage for a pit band, and they went from the 6th of December till about ten days ago, doing the work perfectly well, and although I had taken them off they might, with some repair, have gone for some months longer. I have no hesitation in saying the Thorncliffe pulley is the best of anything of the kind I have ever seen, and I can quite recommend it to anybody. I have seen nothing to require me to change from it.

The PRESIDENT—I think you have had some slight experience as to the wear of the pulleys?

Mr AUSTINE—I am not able to tell you from experience, there has not been time. The great thing is to make it strong. We commenced at Allanton in a small way, and had to feel our way. We had some breakages, but these were not the fault of the pulleys. I may say in my visits to the collieries in England that all the gentlemen who had experience recommended the engines to be below ground, to do away with the rope in the pit, but to have the boilers on the surface.

The PRESIDENT—I am glad to hear that.

Mr BIRRELL—I came hear to-night to hear what was to be said on this question of haulage. It is a question which has interested me not a little, and I am rather anxious to hear the opinions of those present who have had so much experience in this department of coal mining. I may say that I should like specially to hear remarks as to the economical working of the endless rope as contrasted with the endless chain system. I should like to hear something more about the latter, for, as far as my enquiries and investigations have gone, I have a decided leaning to the endless chain system—where it can be applied—over any other that I have yet heard of. It commands my preference because of the ease with which the hutches can be attached and detached; and, in the long run, I believe it is the cheapest.

Mr BORLAND—There is a question I would like to ask about the surface haulage. The rope appears to run from No. 6 to No. 7, Plate II., and I would like to ask Mr M'Farlane how many lines of rails are at No. 2 shaft and how the connection was fixed —if in front of the waggons or at the side?

Mr M'FARLANE—There are four lines of rails where the rope is used, and the grip can be taken either at the centre or at the side of the waggons connected at any place along the line.

Mr BORLAND—Was there no difficulty in moving the waggons at particular points?

Mr M'FARLANE—No; it is simply a matter of a longer chain.

Mr DIXON—The whole thing is a matter of the life of the ropes. I would like to ask how long the surface rope haulage lasted, and what kind of rope it was?

Mr M'FARLANE—In regard to this surface rope haulage, there was part of it old rope that had been put into some of the roads in the pit, and it wrought a short time and was put in here. It was made up just of spare pieces, some of common steel wire, although all steel wire less or more, and of the same diameter. It has been on fully four years now.

Mr AUSTINE—I may add, from anything I see about the rope, it is likely to go other four years.

The PRESIDENT—Have you given the gradients?

Mr M'FARLANE—Yes.

The PRESIDENT—And, I suppose, although you had a locomotive, you would prefer this?

Mr M'FARLANE—Yes; you can work that at any point where you have ropes and effect a great saving. I made my calculations rather less than what the saving was over former years; there falls to be added £158 3s 4d.

The PRESIDENT—We will take your word for it, that, speaking as a practical man, you think it a good thing?

Mr M'FARLANE—Yes; the only great difficulty was to get a proper grip so as not to injure the rope, which we have now got with the use of present grip.

The PRESIDENT—Mr Birrell was asking some questions about the chain: you do not say much about the chain haulage,—only mention it incidentally?

Mr M'FARLANE—As far as I can see, where it can be used in practice, I would prefer the chain haulage to the rope haulage; but you cannot use it nor properly manage it where you can use and manage the rope. Where it can be used, it is before the rope in point of cheapness and every way.

Mr FAULDS—The chain at Dykehead has been working for seven or eight years, and the only objection to the chain is that in working it you cannot overtake branch roads so well as you can with a rope. I know of a chain having worked, I may say, for the last five years, and there is not much wrong with it yet. It has during that time worked a dook 1 in 5. We have had some ropes which have only gone as many months. The present one, of Bessemer steel, 2″ circumference, has only gone about five months, and is completely done.

The PRESIDENT—Do you draw any distinction betwixt the ropes being under the train or on the top of it?

Mr FAULDS—I am driving the rope under and the chain above the hutch.

The PRESIDENT—Suppose both were on the top?

Mr FAULDS—I would prefer the chain to the rope for economy although both were on the top of the hutch. The chain requires a straight line. You can vary any length by putting on wheels when a deviation from the straight occurs. The road at Dykehead is perfectly straight, and in such a length, I think it might have been 3 feet off the straight. The chain is pretty elastic about the centre. If on a dook road, of course a bend is against it.

Mr TELFER—I may say we have had an endless chain working for eight or nine years on the top of the tubs; also, extensive rope haulages, but they are all underneath the tubs. The systems are not exactly the same. I would prefer the rope after eight or nine years' experience of the chain. I find the chain extremely heavy on the tear and wear of the tubs. The gradients on the road are rather heavy—1 in 4 and 4½. The attachment is on the centre at the one end. The upkeep of the tub is much heavier than with the endless rope system. If I had it to do over again, I would have no chain.

The PRESIDENT—I was looking at a chain haulage, as to the wear and tear of the hutches, and I saw that there was a considerable tear and wear on the end on which the plate was. I asked the joiner, who was repairing them, whether it would not be better to put an iron strap round about the hutch to hold it together? but he seemed to think it would be better to make that the weakest part, seeing that if a break took place it would be better there.

Mr RONALDSON—With regard to the point of the comparative durability of an endless rope and chain, I know an instance of an endless rope working on the surface letting the coals down from a high hillside to the valley below. It is worked by a Fowler's clip pulley, has been on for six years, and looks as if it would last a few years longer. It has let down 600 or 700 hutches a day, and it seems to work remarkably well. I did not ask as to the upkeep of the Fowler's pulley, but I was told that it was not very much.

Mr DIXON—What is the attachment?

Mr RONALDSON—By jiggers at the side. One objection is that it is sore on the wheels and rails in consequence of the friction.

Mr BIRRELL—I should like to have some more information about the average length of the life of the rope. A few days ago, I was speaking to a coalmaster in our neighbourhood on this very question, and he mentioned that he was seriously thinking of giving up rope haulage and going back to the old pony system, because of the heavy expense of having so often to replace the ropes. His system is the "Tail haulage." Another thing is—the method of attaching the hutches to the rope—I mean singly. Can any one tell me whether this can be done as easily and as quickly as with the chain? I know that several methods, such as the crook above, or more recently the sort of clip that catches the rope underneath the hutch, professes to do this, but can any of the members present tell me, from actual experience, whether either or any other form of attaching hutches singly has proved in actual working to be efficient and thoroughly reliable? I put some stress upon attaching the hutches singly to the rope, for I believe that in this way you can do far more work with less tear and wear on plant and at less cost than by running them in races. Besides, I believe it has this other advantage—that in the case of hauling from two or more pits with the same engine—especially if one or both be partly up an incline—you do not run the same risk of overpowering your engine when the hutches are put on singly as you would were they run in races. These are the points on which I have my doubts, and which, with this other, viz.—that a chain will, I believe, outlast at least three or four steel ropes, makes me meanwhile prefer the chain to rope haulage; but I should like to hear the opinions of others on the questions here raised.

Mr HASTIE—I could give the gentleman my experience of three ropes on one road. The first rope, the length of which was 4,500 yards, worked for fifteen months and nineteen days; it hauled 135,000 tons; the coals were hauled an average of a mile in length, and the cost of rope was about ¾d per ton. That rope was taken off, and another was put on which went fourteen months; the road was about the same length; it hauled 125,000 tons, and the cost was about the same. The third rope

went thirteen months and a half; it hauled about 125,000 tons, and it cost about the same. I may say the next rope was 4,200 yards in length and only lasted seven months. It was a complete failure, but the makers allowed for it. I should state also the number of hutches working on the rope was 144—12 attached to each bogie. We have had it tried all ways, but adopted the bogie system. The working cost per mile over the whole, in addition to the ¾d for ropes, was 1d per ton.

Mr BARROWMAN—I might refer to what came under my own observation in Victoria Pit, which doubtless some of you have seen. The circumstances were very favourable for the rope. The dook was perfectly straight, and the inclination regular. When mechanical haulage was first introduced there, they worked the dook with a gin and horses, with Fowler's clip pulley. The pulley wrought well. The rope was ⅝th, or ¾th steel, and I remember distinctly the manager telling me it had been on between three and four years. The hutches were put on singly; each was attached to the haulage rope by a short hemp rope, the one end of which had a hook to be fastened to the draw-bar of the hutch and the other end (its stands unwound for about a foot of its length) was rapidly twisted round the haulage rope. I have not seen the same mode of attachment elsewhere, but it seemed to work satisfactorily, and the only labour required was a boy at the bottom and the engineman at the top. The quantity drawn might be 150 tons a day. I think the dook would be fully a quarter of a mile in length.

Mr MALCOLM—A place I may mention has come into my mind viz., Fence Collieries, where they attach the hutches to the rope singly, or in 3 or 4, and run them down an incline, of about 1 in 5 for 200 or 300 fathoms, and they take up the empties at the same time. They attach them the same as the carriages at Cowlairs.

Mr DIXON—It is the same company's pits that Mr Barrowman refers to.

Mr TELFER—We have a long road, somewhere about 500 fathoms, worked by an endless rope. When we commenced it we ran trains of six or eight tubs, attached to the rope by a bogie with screw clamp. On a part of the road there is an incline

of 1 in 4 and 4½. The trains of full tubs coming down rather overran the engine. At the top of the incline we put sprags into the hutch wheels, which very soon destroyed them. We changed the system of working, and now we have trains of three tubs placed about 100 fathoms apart on the rope. The speed of the rope has also been reduced from four to two and a-half miles per hour. The road is perhaps an exceptional one. For about 200 fathoms from the shaft it undulates, the next 100 fathoms it rises 1 in 4 and 4½. At the top of this incline the road makes an angle of 45 degrees, which is passed round by a curve of 50 feet radius; for about 30 or 40 fathoms beyond this curve the road continues to rise 1 in 8, and then makes another angle of 45 degrees, where there is a curve of same radius as the former one. A small portion of the road here is level, and the remaining 150 or 160 fathoms dip 1 in 8 or 9, so that there is always a train of loaded tubs coming up this portion of the road, while another train of loaded tubs is going down the 1 in 4 and 4½ incline. That load has been worked on one rope for five and a-half years and is working still, although I have no hopes of it working very long now. The quantity drawn is about 150 tons a day, but the rope does not go above six or seven hours. The engine is on the top; the pit 80 fathoms deep. The rope is a plough steel one. We have another rope in another seam doing the same amount of work on an incline 1 in 10 or 12, rising with the full tubs. It has gone two and a-half years and is likely to go as long again. It is only an ordinary steel rope.

Mr CLARK—At Carberry, they wrought on the jigger principle, and the ropes there went two years, and with Fowler's pulley about four years.

The PRESIDENT—The late Mr Thomas Moore, one of the owners of that colliery, told me that had he the thing to do over again he would put on a chain instead of a rope. The road there is about 800 yards long, rising from 1 in 3 to 1 in 4, and perfectly straight and dry, with nothing, as far as I know, like water and sand to injure the rope. The rope goes on the top of the hutches and is attached by the ordinary "jigger," and in every way works well. Any quantity can be raised.

Mr ANDERSON—I would like to ask if any gentleman has any

experience of a full load on coming down from the face. The way Mr Telfer has it working the full load near the pit-bottom neutralises the race on the other side. Suppose the full ones had to fall from the face to the pit bottom, I would like to know how the difficulty is overcome of the rope doubling in front of the race. I should be very glad to have some information on that point.

Mr TELFER—We found that to be the case, and we put a chock in front of the tightening carriage to prevent the slack coming from the empty side to the full. I have seen the rope nearly get into a loop in front of the loaded tubs, but by putting the chock in front of the tightening carriage it prevented this.

Mr ANDERSON—Where is the tightening carriage placed?

Mr TELFER—The tightening apparatus was at the top, but it is now in the pit bottom.

The PRESIDENT—I should like to ask Mr Grant, now that he is here, if he has any difficulty in making the Thorncliffe pulley?

Mr GRANT—The only difficulty we had was in connection with the first one. It was turned in the lathe, and when tried, it was found that the load made an impression or indentation into the rim of the pulley. When Mr Austine asked how I could cure that, I said they must be made in chilled moulds, and this succeeded. The rim must be perfectly true, and you can only manage this by either turning them or casting in chills; but, with a heavy load, when the skin is taken off the casting, the rope is sure to cut into it, and chilling the face entirely prevents this. When we tried this pulley first at Allanton, I thought the rope would not come off the pulley in a straight line, but, with the strain on the rope, it would require some effort to relieve itself, but this never happens—it comes off quite straight.

The further discussion of Mr M'Farlane's paper was adjourned.

Mr WILLIAM CROSSLEY then exhibited and explained his "Patent Compressed Air Safety Lamp," a full description of which he handed to all the members present, the discussion of which was delayed till next meeting.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 10th JUNE, 1881,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

RALPH MOORE, Esq., President, in the Chair.

THE Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members :—

WILLIAM CROSSLEY, Iron Merchant, 153 Queen Street, Glasgow.
DAVID GARDINER, Coalmaster, Meiklehill Colliery, Kirkintilloch.
GEORGE A. MITCHELL, Glenclelland Colliery, Wishaw.
H. STEWART, Manager, Tranent Collieries, Tranent.
THOMAS DEWAR, Manager, Glenclelland Colliery, Wishaw.
ROBERT TENNANT, Manager, Springbank Colliery, Airdrie.
THOMAS GARDINER, Jun., Manager, Auldton Collieries, Dalserf.
THOMAS IRELAND, Manager, Largoward Colliery, Kilconquhar, Fife.
WILLIAM GILLON, Oversman, Townlands Colliery, Hamilton.
WILLIAM WILSON, Fireman, 40 Holygate, Broxburn.

Other nine gentlemen were then nominated as Ordinary Members, and will be balloted for at the first meeting.

DESCRIPTION OF A SAFETY LAMP.

Mr W. J. A. DONALD, Eglinton Chemical Co. (Limited) of Glasgow, Irvine, Glenarm, and Ballintoy, exhibited and described a Patent Safety Lamp. He said—Mr President and gentlemen, I was not prepared to submit a paper in showing to you these lamps, and I think I can perhaps state in a very few sentences all that can be of much interest to you in connection with them. In the first place, I would like it to be known that this is the invention of a German friend, Dr. C. Heinzerling, Frankfort-on-the-Maine, who, on a recent visit, brought this lamp across with him to show it to me, and who, on that occasion, met Mr MacCreath, who seemed to think it might be worthy of exhibition at your meeting here. I have, therefore, no personal interest in the matter whatever, and I have no practical connection with coal mining.

Now, to begin, I may tell you that the object of the lamp is to enable a mineral oil to be a substitute for vegetable or other oils in safety lamps in mines. As I understand it, such a thing is impossible in connection with the ordinary Davy lamp, because of the great heat which is generated in the lamp, and which would be sufficient to bring up the mineral oil to the flashing point, and, therefore, make it dangerous instead of being safe. By the simple contrivance here (showing), mineral oil can be used with perfect safety. You may see here that I can place my hand constantly on the top of the lamp while it is burning. That shows that but little heat escapes here (showing). My hand is on the gauze at this moment, and my hand is not uncomfortably warm; the lamp above and around the bottom is perfectly cool, as you can also feel.

While keeping the one lamp burning, I will take this other one for the purpose of explaining the parts of the lamp. I take off first of all the outer case for the protection of the lamp. I cannot tell the weight, but it is not heavy. The top part here (showing) comes off, and this here (showing) consists of a casing of wire gauze. The top of this comes off, and discloses in the interior here (showing) what is called glass wool,—it is wool made of very fine glass,—glass pulled out into mere threads. It is the glass wool that serves as the agent for radiating the heat and preventing the top of the lamp from getting warm. It also serves

another useful purpose, as, I understand, it filters the air before it passes into the lamp, and thus frees it from coal dust or dust of any kind. Dust cannot get into the lamp without being filtered by that fine glass wool. That (showing) is simply for the purpose of receiving the heat from the burner. This (showing) fits in here.

The PRESIDENT—Generally, there is india-rubber at the top and bottom of the glass cylinder.

Mr DONALD—That has not been supplied, but it can be done. I now take up the lamp proper. That (showing) comes off in the first place, and the chimney, which is the director of the light here, in the second place, and this (showing), the wick holder, comes next. This (showing) goes on the top, and you have here simply a repetition of what you have at the top. That is also filled with glass wool, as you can see, and the air for combustion passes through the wire gauze round the bottom of the lamp. I will just put the parts together again. The top of the lamp fastens it to the frame in connection with this ring on which the glass barrel stands. There is a little round screw for turning from the outside the light up or down.

Now, the advantages that the patentee claims for this lamp are —first, great saving which it enables one to make by using mineral oil, which can be had, the very finest, for about 1s a gallon, as against the oil at present used, which costs 3s to 4s a gallon. That must make a very important saving. The second advantage is the increased light. Here, I think you will all admit, is a very superior light to the ordinary Davy lamp. Well, then, in the third place, you have the protection here against coal dust or any kind of dust getting into contact with the flame of the lamp, because no air can get into the lamp without being filtered between the fine wool.

I think I have now said all that is necessary to explain the lamp, but I may just add this, that Mr MacCreath put one question to the patentee, Dr Heinzerling, and I shall just repeat the experiment which he made at that time. The question was, suppose that lamp falls down on its side, would the paraffin or other mineral oil ooze from the oil box into the lamp and then possibly get ignited, or would it put out the lamp or get into a

blaze? The Doctor said he had never tried it. Mr MacCreath immediately turned the lamp upside down, and I am glad to say, with the same result as now, it put out the light. So, there can be no danger in using this lamp in the pit.

The PRESIDENT (to Mr Anderson)—How does that differ from Teale's?

Mr ANDERSON—I think it is much the same unless the construction.

The PRESIDENT—The real new point appears to be at the top and bottom; the lamp must draw air through a filter, and the products of combustion pass through a filter. As for the use of mineral oil, I suppose that has been in use for years.

Mr ANDERSON—We use Teale's lamp wholly. I think it is a safer lamp than that, for in opening it the light goes out.

Mr MACCREATH—Does it give as good a light?

Mr ANDERSON—I think so.

The PRESIDENT—Is it on the same principle?

Mr ANDERSON—Yes, and it is narrower. Then you cannot possibly open the lamp without putting it out. But even if it is locked you cannot put it out.

Mr BEITH—Could Mr Donald explain if the lamp, after being perpendicular, is slowly turned up for a moment, will it go out?

Mr Donald made the experiment, and the lamp went out.

Mr MACCREATH—I waved the lamp and it did not go out.

Mr BEITH—The Protector lamp goes out.

Mr DONALD mentioned that the prime cost of the lamp, without any royalty, would be 5/ or 6/.

The PRESIDENT—I suppose, gentlemen, you will be inclined to say that the top and bottom with the filter is new to most of us here, but that the burning of paraffin oil is of daily use. I suppose you will authorise me to give Mr Donald a vote of thanks for his kindness in coming and exhibiting the lamp. As he has explained, he has no interest in the matter. (Applause.)

Mr DONALD—I am much obliged to you for the vote of thanks. It has been a great pleasure to me to come and explain the lamp. It is only because of the friendly interest I have in it I am here, and should it be wished I shall be glad to leave it for a few days.

Mr Anderson offered to try the lamp, and it was also, on the suggestion of the President, agreed to appoint a committee to report upon it.

MR M'FARLANE'S PAPER.

The PRESIDENT announced that the next business was the discussion of Mr M'Farlane's paper, which, although he was absent, would be proceeded with.

Mr BISHOP, in reply to the President, said he had nothing to add to what Mr Austine said last night, further than that the Thorncliffe pulley was still giving satisfaction.

The PRESIDENT—Suppose you were going at ten miles an hour instead of five, would it make any difference, would there not be some wear?

Mr BISHOP—I do not think it would make any difference. We have not tried it any quicker than three miles an hour; of course, we do not require to go any quicker.

The PRESIDENT—I think there are some points which we are in the dark about—first, as to the wear and tear of ropes and the best kinds of pulleys; next, as to the grip which is against the wear of the ropes; and, thirdly, as to the mode of taking turns—whether by means of one pulley or a series of pulleys, according to the curve. These are all points on which we want information, and which would make a paper of this kind valuable. Of course, you know if it is such as Mr Dixon's haulage, where the hutches carry the rope, the friction due to the fixed pulleys is saved. Has any gentleman any experience as to the life of a rope with the pulleys fixed and with the hutch carrying the rope?

Mr FAULDS—At last night's meeting, Mr Birrell asked to hear remarks on the economical working of the endless rope as contrasted with the endless chain system, and Mr Telfer said "that after having nine years' experience of the chain he prefers the rope, and that the tear and wear of the tubs with the chain haulage is very considerable." The principal tear and wear of the chain is on the driving wheel, and depends very much on the

style of attachment to that wheel, and also on the tubs, as Mr Telfer says. Where there is a change of gradient on dook roads there is some little difficulty in keeping the chain attached to the tub. Branch roads on dooks can be worked with branch chains, but on flat gradients they can be worked simply by a lever with small wheel on end for raising chain and detaching tub. Am I correct when I say that all chain haulages are attached to the top of the tubs? With the rope haulage the tubs are generally run in races with bogies in front, and also with clips only. The tubs are also put on singly with a jigger, but it seems that this mode of attachment is more suitable for flat than steep gradients. Some of the members here may have observed (when visiting Colonel Beaumont's Boring Machine at Benhar) the Coltness Iron Company working a long road on the surface in that neighbourhood with a fair gradient with the rope on the jigger principle, but which attachment was working very unsatisfactory at that time, causing detachments, daily resulting in the breaking of the tubs. There are some very steep gradients being worked in the Eastern (Edinburgh) district with the rope on this principle, but are the detachments not frequent? With the bogies the detachments are with clips, and are of various designs, the Hanson being very good, and also that employed in our own district at the Bent Colliery, which is very simple, ingenious, and effective. The principal tear and wear of the rope is caused by so many wheels at deviations in opposite directions, so that the best principle and easiest on the rope, if at all possible, is to have the rope always going in one (or a circular) course similar to that in use at Bent Colliery. The advantage gained by the jigger attachment like the chain is the equal distribution of the load, and consequently a steady speed if the gradients are uniform, but running the tubs in races with bogies on steep gradients the speed is not so steady, and has to be checked when the load is coming down such gradients. Mr Anderson asked at last meeting if any gentleman had experience of this, and he was answered by Mr Telfer. Mr Telfer's remedy was by putting a chock in front of the tightening carriage. Would Mr Telfer inform us if it was an improvement in placing his tightening carriage below instead of at the top? In hauling our tubs down steep

gradients we found the same thing to occur with the rope, and on one occasion it became loose in front of the bogie attached to the tubs; that part of the race went over it, and we were compelled to put chocks in front of the back-balance wheel on surface. Mr Hastie has given us the life of his ropes which, I presume, work on the Bogie principle in races. The average life of our ropes is eleven months. The average length of each rope is 3500 yards, and the circumference of each about two inches. In the *Shenandoah Mining Herald* of 7th ult., an American publication by the Mining Institute of Pensylvania, I observed an article on Hoisting Machinery with one rope for two roads at present in operation at Packer Colliery, No. 3, of the Mahanoy Division of the Lehigh Valley Coal Company. It was just a modification of some of the haulages in our own district, with the exception that there were more wheels on the surface. This is a new Institute just established in Shenandoah. Might it not he advisable for the Council to see to this Institute exchanging papers with them?

The PRESIDENT—I am glad that Mr Faulds has prepared some remarks, but he has not addressed himself to the point which I think is important—that is, in taking a curve whether to have one large pulley or a number of small pulleys.

Mr TELFER—On tail-rope roads I have tried, in going round curves of 22ft. radius, three 3ft. pulleys where we used to have eight or nine 15in. pulleys. It was a great improvement, but I have never tried it on the endless ropes' curves. Mr Faulds asks whether it was an improvement to have the tightening carriage at the bottom of the shaft. When at the top of the shaft, it required 18 cwt. of load to keep the rope tight on the driving drums, and after taking the carriage to the bottom it only requires 1½ cwt. When the carriage was on the surface the heavy weight was partly required to counterbalance the rope in the shaft, and we do not require to do that with the carriage at the bottom.

The PRESIDENT—No doubt the 3ft. pulleys are better than the 15in. ones. Has any one any experience as to the life of the rope on these as compared with the large pulleys?

Mr TELFER—In the case I refer to, the ropes wore nearly double the time on the 3ft. pulley. I think I said we had an end-

less rope 5½ years in use. I take the extra life of that rope to be the result of the large size of the pulleys and curves. There was no pulley less than 6ft. dia. at the top or bottom of the shaft, and no curves having a radius less than 50ft., the rope being taken round them with small pulleys.

The PRESIDENT—In taking a curve round a radius of 50ft. with small pulleys, is there not much tear and wear? Would it not be worth while to have larger ones?

Mr TELFER—No.

Mr BISHOP—We have some 15-inch pulleys. The curve is about 20 degrees, and the smallest radius inside the rails is 30ft. The pulleys are put in 3ft. apart, and seem to work well enough, but they wear very soon.

Mr TELFER—These small pulleys in our case worked for 5½ years without being changed, so they did not seem to wear very quick.

Mr RONALDSON—There is one objection I see to the chain which has not been mentioned, and that is, you cannot heap the coals above the frame of the hutches where the chain passes over the centre. In many cases, where there is a large output, it is very important to have as much weight on the hutches as possible.

Mr ANDERSON—Mr Faulds mentioned, I think, a 3ft. pulley taken round the curve. Does the one pulley complete the circle? are the hutches detached at the place, or do they still keep a grip of the rope?

Mr FAULDS—The hutches are detached before coming forward, and are attached after passing over the pulleys, both on empty and load roads, the gradients being made to suit that.

The PRESIDENT—I think, in regard to Mr Ronaldson's objection, I have seen very large hutches where the chain has two catches—one for the loaded tub and one for the empty.

Mr W. S. RUSSELL—At Summerlee, they load their hutches eight inches in the centre and 10 inches at each side, and the centre forms a gutter where the chain moves.

The PRESIDENT—Then you did not find any difficulty at Summerlee.

Mr WILSON—When the chain was introduced at Dykehead

they added 4 to 6 inches to the height of the hutch, and, although they left a gutter in the centre, they held fully more coals than before. It has no more top weight than a hutch of ordinary depth piled up.

Mr MALCOLM—In a comparison of the chain and rope haulages, is there much difference in the up-keep of the hutches?

Mr FAULDS—I consider—and Mr Telfer says the same thing—there is more tear and wear with the chain than with rope haulage.

The PRESIDENT—That is inasmuch as the tubs are attached at a vulnerable point.

Mr FAULDS—Another thing, in the case of a rope breaking and a chain breaking, there is not a great deal of difference in the repairing of them, because a rope is easily spliced, while, as regards a chain, though there is no difficulty in putting in a link, there is a difficulty in getting the chain to meet to enable you to do so.

Mr RONALDSON—What is the relative first cost of the chain as compared with rope? Has any one any experience of that?

Mr FAULDS—I have scarcely got that completed, but I may have it before the Transactions are out.

Mr TELFER—I think the relative first cost is in each case almost the same. The cost of the chain alone is pretty much the same as the rope, rollers, &c., required.

The PRESIDENT—Because the price per cwt. of the one will be much less than the price per cwt. of the other. If there are no other remarks, I think we will close this discussion, which has brought out a number of points. We have had some valuable remarks from many of the gentlemen present; and it just occurs to me, and to some of the gentlemen near me, that Mr Faulds would do much good to the Institute, since he has so much information, if he would contribute a paper contrasting the cost of the two systems more at length, and taking up some of the points that have been objected to. You will give Mr M'Farlane a vote of thanks for the trouble he has taken in preparing a paper for us. (Applause).

MR CROSSLEY'S LAMP.*

In the absence of Mr Crossley, the discussion of his safety lamp exhibited at last meeting was further adjourned; and the meeting afterwards separated.

On the motion of the President, Mr Crossley's lamp and that of Dr. C. Heinzerling were remitted to a committee to report.

REPORT BY DEPUTATION ON METHODS OF SUPPORTING THE ROOFS AND SIDES.

AGREEABLY to the instructions of your Council, we visited collieries in England, Scotland, and Wales, and we now beg leave to make the following report as to the modes of supporting the roof and sides practised in these mines :—

We were underground in 18 collieries, examined the faces and saw the mode of propping and securing the roofs and sides, and the modes of working adopted.

We found the system of propping so inseparably connected with the mode of working that we have described at some length the various modes adopted, and have given plans of part of the workings reduced from tracings of the colliery plans kindly furnished us by the owners, and have thus been enabled to give an accurate idea of the modes as they are actually carried out.

We have called those workings long-wall where the whole face is taken away in one working, the distances varying from 200 yards to a mile in extent; we have called those pillar and stall where blocks of coal of any size are left. The largest of these was 140 yards square and the smallest 12 × 55.

We have called the roofs good or bad as in our opinion they should be called when compared with Scotch roofs. With regard to the modes of supporting the roof, Northumberland and Durham were the only places where the deputies were responsible for propping the roof; but in a Derbyshire Colliery, a Yorkshire Colliery, two North Staffordshire Collieries, and a South Staffordshire Colliery where the workings were by the long-wall method, and the walls were very long, they were under the charge of parties called stallmen who employed workmen to hole and take down the coal while they or a special set of men employed by them—but neither specially proppers—put in the props and

buildings. A deputy in the North of England attends to 10 or 12 men. The stallmen has from 8 to 16 men under him, so that although a stallman is not an official acting on the part of the owners, still it may be called an approximation to the Durham system. In all the other places the props were put up by the miner or persons working at the face.

Only in one instance, that of Cannock Chase Colliery, was any distance specified at which props should be set, although in many places there was an understood distance not to be exceeded whether the roof appeared good or bad. There was no regulation to this effect in any of the special rules.

With regard to sprags and props to keep the coal from falling over the distance between these was fixed by the special rules in many instances. We have described at page 63 a peculiar form of sprag called a cocker sprag, which is used to prevent tender coal from falling over.

In all cases supporting of the main roads was done by men specially appointed for the purpose as in Scotland.

As a general rule the walls in Derbyshire, Yorkshire, and Staffordshire were very much wider than in Scotland, and the collier holed under the coal—usually in daugh—the extraordinary depth of from 5 to 6 feet.

At Pemberton, where the walls were 30 yards wide, the roof was broken over chocks in order to save building and keep the weight off the face.

We have noticed a peculiar form of shearing at Lundhill, where the collier cuts 9 feet in advance of the face.

There was nothing in particular about the stoop-and-room workings. In some instances in taking out the pillars, packwalls were substituted for props and these were allowed to remain, whereas the props were drawn out; but this did not seem to effect either the economy or the safety of the working.

The double stall system at Celynen was unique.

In all the English collieries, with the exception of Celynen and Risca, all the props were withdrawn when no longer needed. Beyond this there seemed to be no great variation from the ordinary Scotch practice.

We have given a table showing the quantity of coal raised in

each district per life lost from falls of roof and sides for the separate years from 1873 to 1880, which shows the comparative safety of the various districts.

The details of the collieries we visited are annexed.

Upon the whole matter we have respectfully to say that in our opinion the north of England system of employing deputies is not to be recommended, but rather that the other and almost universal system should continue and be improved in a fashion such as they have adopted at Cannock Chase. That is that each seam or working should have prescribed by the manager a rule stipulating the extreme distance between the props and sprags.

We have only to add that, through the kindness of H.M.'s Inspectors of Mines in the various districts, we had introductions to collieries in their districts which were best suited to our purpose, and we have to thank them very much for their attention. We have further to notice the extreme kindness of those gentlemen whose collieries we visited. We were cordially received, shewn the utmost attention, and every enquiry we made was satisfied.

We are,
Gentlemen,
Your obedient Servants,

HENRY MUNGALL,
Of Cowdenbeath Colliery, Fife.

JOHN DRINNAN,
Manager, Arden Collieries, Airdrie.

ROBT. THOS. MOORE, C.E., B.Sc.,
Rutherglen.

HAMILTON, *20th June*, 1881.

NORTHUMBERLAND AND DURHAM DISTRICT OF INSPECTION.

The special rules as to propping are :—

4. *Deputies.*—The deputies are responsible for having ready, and putting into every working place a sufficient quantity of timber, brattice, and other materials, and for setting sufficient

timber to afford the greatest possible safety to the workmen employed, and to report any deficiency of timber, brattice, or other material to the overman or back-overman.

8. *Overman.*—To see that there is a sufficient quantity of props, timber, and other material sent into the pit and into the districts where needed, and to report any deficient supply of timber or other material to the manager or underviewer.

14. *Workmen.*—Should the working place of any man or boy become unsafe from any cause, he is to discontinue working in it, and immediately send for the deputy; but if unsafe from want of timber being set, then, in the absence of the deputy, there being sufficient timber of proper lengths in the place, the hewer to set it, in order to keep himself safe, or cease to work and report the same to the overman, and in all cases, where necessary, he is to sprag his jud of coal while working under it.

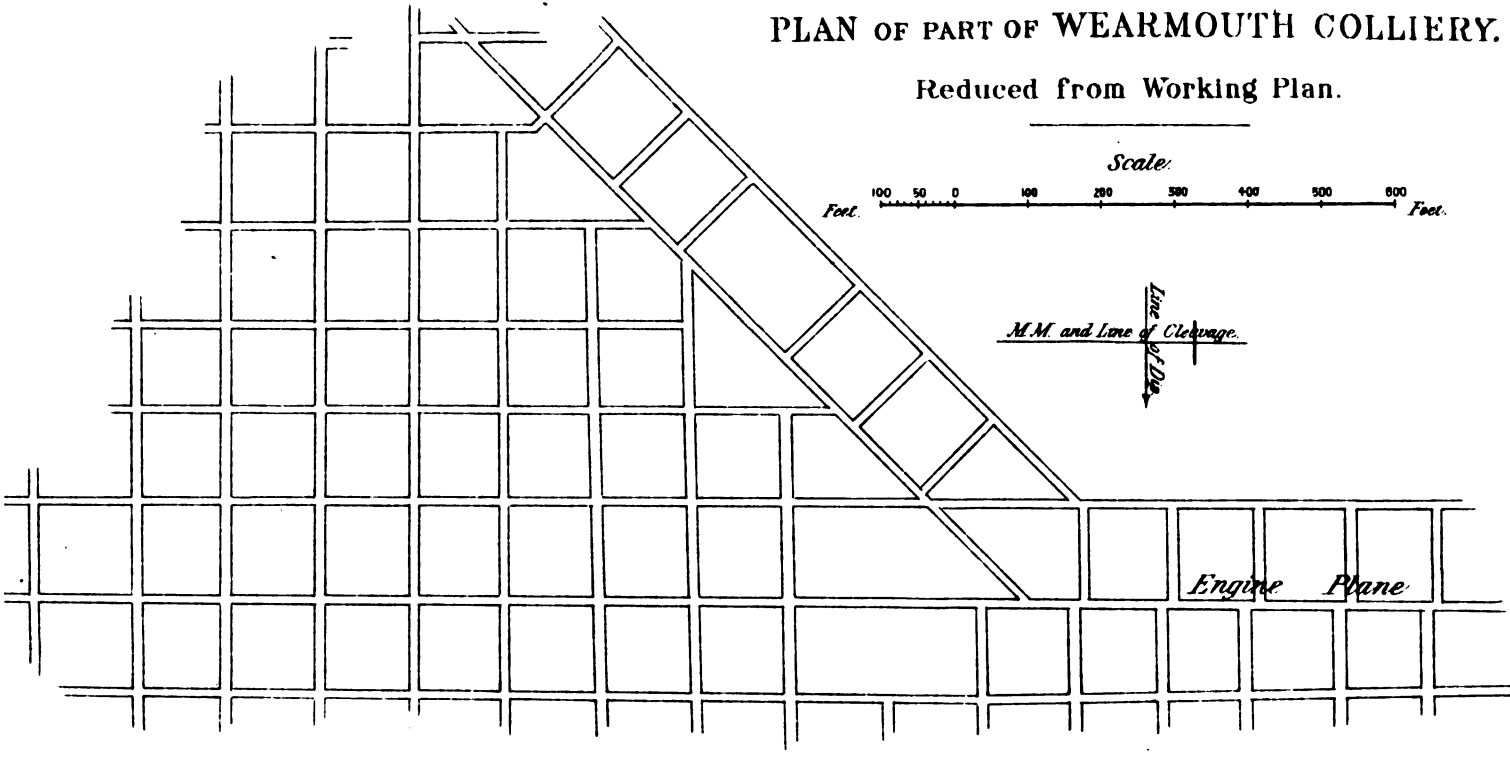
Monday, 4th April, 1881.—WEARMOUTH COLLIERY, SUNDERLAND.—Owners: Messrs Wearmouth Coal Co. (Limited)—Agent: Mr M. W. Parrington.

The sinking of this colliery began in 1826, and it has been working coal since 1835. It consists of two shafts, an upcast and a downcast; the former 11ft 6ins. diameter, and the latter 12ft. 6in. Coal is wound by both shafts, and the output is 2000 tons per day of 24 hours. Each cage has four decks, carrying two 8-cwt. tubs in each. The ventilation is caused by a furnace 144 square feet area of firegrate, placed in the Maudlin seam, helped by the furnaces of six steam boilers. The total quantity of air is 180,000 cubic feet per minute, but in the winter months it often reaches 200,000, and often more.

The workings at present are in the Maudlin and Hutton seams, the former at a depth of 265 fathoms and the latter 287 fathoms. The general dip is to the east; but it is so flat that roads can be made in any direction without inconvenience. The distance of the coal face from the shaft in most of the district varies from 2 to 3½ miles, and the coals are brought out by

PLAN OF PART OF WEARMOUTH COLLIERY.

Reduced from Working Plan.



the tail-rope system of haulage, there being more than 20 miles of steel wire rope in daily use in the pit. In one of the longest planes, where the empty race goes in as the loaded one comes out, there are 126 tubs on the road at one time.

Our observations were confined to the Maudlin seam, which is worked by the pillar and stall method. The pillars are 40 yards square, the openings—one 12 feet and the other 9, the roads being laid on the narrow places. A plan of part of the workings is shown on Plate III. The working is 6 feet

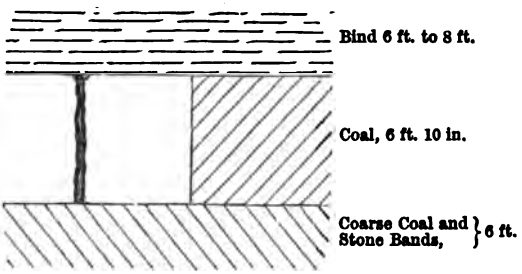


FIG. 1.—WEARMOUTH—MAUDLIN SEAM.

10 inches high. (See sketch, fig. 1). The stratum immediately above the coal is hard shale, 4 to 5 feet thick, above which is freestone, 24 to 30 feet thick. Below the coal is 6 feet of coarse coal with bands of stone running through it, and below this is hard sandstone. The coal is tender, so much so that the workmen do not hole at all, but "scallop" or hack down the coals, working in a standing position. The proportion of dross through a screen with bars an inch apart is 55 per cent.; but this is not objected to as the coal is used for gas-making purposes. In the men's working faces the props are put up by the deputy wherever they are thought necessary. If a man, in the course of his working, however, sees that a prop is necessary, he is required not to wait for the deputy, but to put it up himself, the wood being in his place. In the sample place, which was 12ft. wide, props and

gears were placed about every yard. The two uprights were 3½in. timber, 6ft. high, 5ft. 6in. apart at bottom, and 4ft. 6in. apart at

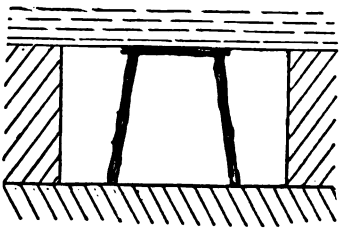


Fig. 2.—Wearmouth—Gears in Working Places, Maudlin Seam.

top. (See sketch, fig. 2). The crown was a 5in. prop split through the middle. The round side was placed next the roof. The rails were laid up the centre of the place.

These props are put in in the ordinary course of working, and are kept in till there is another end through. They are then drawn by the deputies. When this is done, the roof generally falls to a height of 2 or 3 feet; but occasionally it fills the place up. The pillars crumble off at the sides and are not solid.

We saw no pillar-working, but were informed that when they began to a pillar they did so by spliting it and then taking it out by lifts to both sides. A deputy attends about 12 men, who put out about 60 tons a day.

The collier was paid 10d a ton for hewing and filling.

The sample place was not bratticed, neither were any of the others we were in. There being no holing, of course there was no spragging.

This seam had a really good roof. The cost per ton for timber was 1¼d in the roads and solid places and 2d in the pillar-working.

The main roads, where timbered, are timbered with props and gears; at some points the gears were put about 3 feet apart. There are two 4½ inch props, 8 feet long, with hardwood lids 6 inches × 7 inches × 2½ inches, and gears 6 inches square and 9 feet long. If the sides are good, instead of having two side props, the one end of the gear is notched 6

inches into the roof, and a short prop 3 feet long is placed into a notch made in the roof on the top of the coal on the other

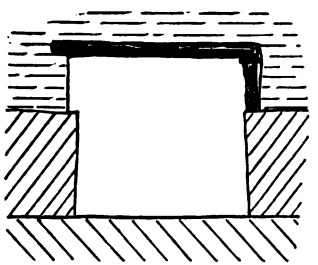


FIG. 3.—WEARMOUTH—GEARS IN MAIN ROADS IN MAUDLIN SEAM.

side.—See Fig. 3. These props in the main roads are put in by men specially appointed for the purpose, called stonemen. They work in pairs, and are generally paid 1s for a 9-feet "balk" or crown, the price varying according to the difficulty in setting. A pair of men put in 10 sets of 9ft. timber in a shift.

The workings are dry, although there are hollows with water in them which is very salt, containing as much as 21 oz. of salt to the gallon. The roads soon get very dusty, but are watered, and the dust cleared up once a fortnight.

SOUTH DURHAM DISTRICT OF INSPECTION.

The Special Rules as to propping are the same as those in the Northumberland District.

Monday, 4th April, 1881.—SILKSWORTH COLLIERY, near Sunderland. Owner: Marquis of Londonderry. Chief Viewer: Mr John Dalglish. Resident Manager: Mr F. S. Panton.

This colliery is quite a new fitting, and works the Maudlin and Hutton seams at a depth of 270 and 290 fathoms respectively. It consists of two shafts, one 16½ feet and the other 14 feet diameter. The output is about 2000 tons per day. The large pit only winds coals and it has four cages in it—two of them winding from the Hutton and two from the Maudlin seams. The

winding engines have each 48 inch cylinders, 6 feet stroke, one pair winds from the Maudlin seam with 25 feet cylindrical drums, and the other winds from the Hutton seam with a scroll drum, 13 to 28 feet diameter. One pair was made by Barclay of Kilmarnock, and the other by the Grange Iron Co., Durham. They are fitted with a very simple and effective automatic variable expansion, a full description of which is given in a paper read by Mr Dalglish before the North of England Institute of Mining Engineers. The cages carry 8 tubs of coal in 4 decks, and are loaded and unloaded at two levels, both at the pit bottom and at the surface. The other pit is used solely as an upcast, and there is a furnace 90 square feet area of firegrate placed in the Maudlin seam. There are three main returns—one 100 feet area, passing 45,000 cubic feet a minute; one 124 square feet, passing 80,000 cubic feet; that in the Hutton seam 100 feet area, passing 70,000 cubic feet; total quantity passing through the shaft, 195,000 cubic feet per minute. The dip is variable, varying from 1 in 6 in one small district to 1 in 18 in the greater part of the workings.

We visited the Maudlin seam, which is worked by the pillar and stall method—(see plan, Plate IV.)—the pillars being 50 yards square, and the openings 12 feet one way and 8 feet the other. The 12 feet places are broken off 8 feet wide, and after going in 9 feet they are widened out to their full width and carried on at that till they are nearly through. When they are 9 feet from the other level, they are made 8 feet wide and put

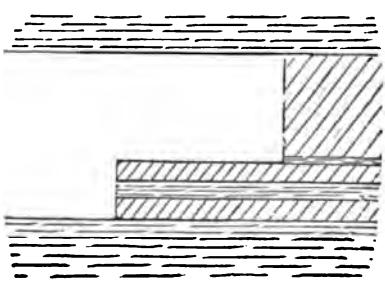
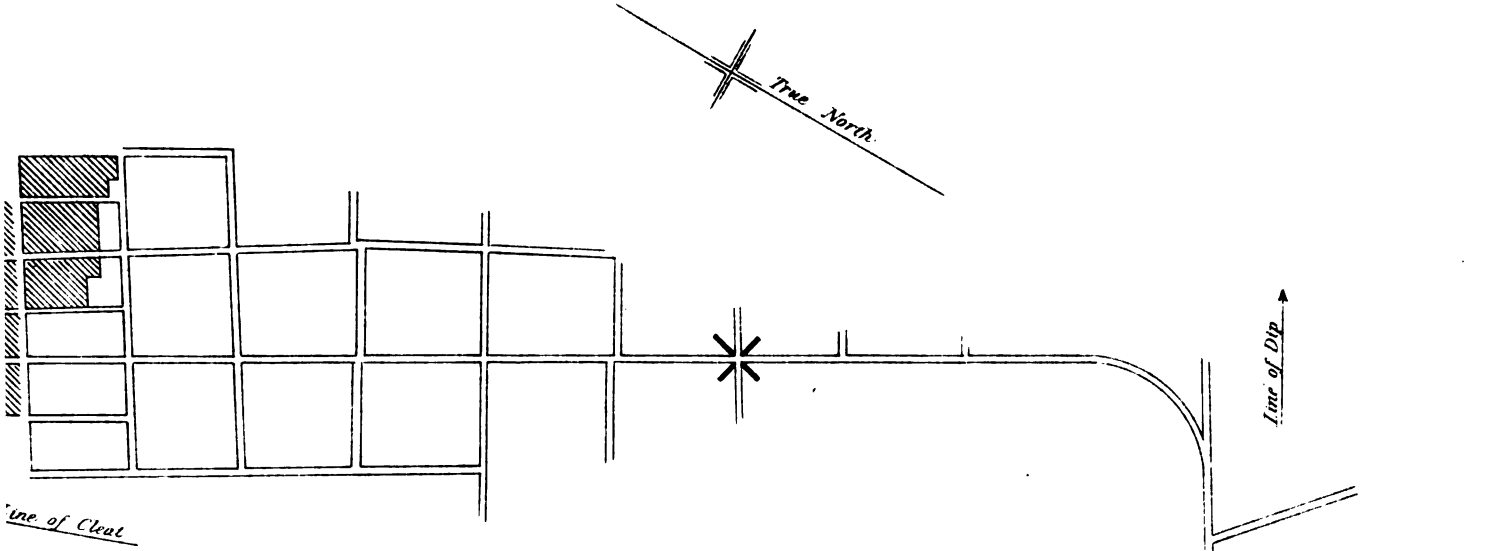


FIG. 4.—SILKSWORTH—MAUDLIN SEAM.

through that width. The working is 5 feet 8 inches in height. (See section, fig. 4.) Immediately above the coal is a bed of



PLAN OF PART OF SILKSWORTH COLLIERY.

Reduced from Working Plan.

Scale

"blue metal" 20 inches thick, and above this are 3 fathoms of post and blue metal mixed. Below the coal come 10 inches of bottom coal, 8 inches of "sagger," or fireclay, and 18 inches of coal, which are all raised in the main roads to give height, but the coals, being of inferior quality, are left on in the ordinary working. Below these come "blue metal," 3 feet, and then 3 or 4 fathoms of sandstone. This is the same seam as that which is worked at Wearmouth, whose workings are within half-a-mile of Silksworth Pit, so that the coal is very similar at both places. The timbering in the main roads is done in the same way as at Wearmouth. In pillar working they take out the pillars by splitting them with an 8 feet place, and then working them right and left from the split and the end, taking a lift 6 yards wide, 20 yards to the rise and 5 yards to the dip. The lifts were taken off the pillars on both sides of the split, and great care was taken to have the lifts "stepped." In some cases, where the roof is good, the lifts are driven half-way up the pillar from both sides. The place is broken off 6 feet wide, leaving 4 yards between the road and the goaf. This is carried on at this width till it is 4 yards in; it is then widened out to the waste, leaving a "stook," or pillar, 4 yards square between the road and the

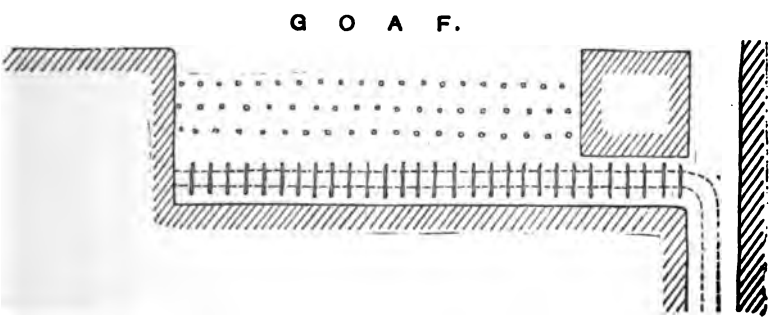


FIG 5.—PLAN OF A LIFT SHEWING PROPS AND GEARS.
(Scale—1 inch = 33 feet.)

waste, and the lift is carried up 25 yards at this width. In the sample place (fig. 5) three lifts had been taken off for 25 yards, the props drawn and the roof had fallen. The third lift, 6 yards wide, was 20 yards up. Two men work in this place two shifts,

and are paid 8d a ton for hewing and filling. The coal was "scalloped" without regard to round coal. There was no holing and of course no sprags. There were props and gears of the same kind as at Wearmouth, placed at about 18 inches apart through the 6 feet opening and over the rails right on to the face. On the waste side of the road there were three rows of 6 inch props about a yard apart. These props were set by the deputy. Although there was no set distance for the props, there seemed to be an understanding that they should not be set more than a yard apart. After a lift is finished, the deputies draw the props after the hewers are out of the pit. The 4 yard pillar, or "stook," is then worked away and the props drawn. If the deputies cannot draw the whole of the timber, timber drawers, who are always spare deputies, are put on to help them. They are paid 8d and 10d a score for taking out the props. This price is paid only on whole timber, unless the broken timber is wanted, when two broken props count as one whole one. A deputy attends to 10 or 12 men, and in addition to putting up timber, sees that the place is right with regard to ventilation. He stands the same hours as the miners, and generally visits each place twice during each shift of 8 hours. He is paid by day's wages.

We saw no solid places here, but were informed that they were worked in exactly the same way as at Wearmouth. This was a really good roof. The cost of timber was 2½d a ton.

YORKSHIRE DISTRICT OF INSPECTION.

The special rules as to propping are:—

29.—The miners must build good pack walls, and set a sufficient quantity of props and bars for safely securing the roof and sides of their own working places, and add to them or renew them when necessary, or when told by the Underground Viewer or the Deputy; and the miners when leaving off work must see that the

pack walls, props, and bars are left in safe order. In mines where the building of pack walls is separately contracted for, the miners shall not be required to build pack walls.

30.—The method of holing or baring the coal shall be ordered by the Underground Viewer or the Deputy, and the miners must set a short prop or "*sprag*" *at least every two yards*, to prevent the undermined coal from falling unexpectedly.

10.—The underground viewer or his deputy shall see that the roof and sides of every travelling road and working place shall be made secure, and a person shall not, unless appointed for the purpose of exploring or repairing, travel or work in any such travelling road or working place which is not so made secure.

7.—The underground viewer or his deputy shall see that packwalls, props, bars, and sprags are put where required.

3.—The manager or the underground viewer shall see that an ample stock of good timber props, &c., is always on the premises.

Tuesday, 5th April, 1881.—KIVETON PARK COLLIERY, Kiveton Park, near Sheffield. Owners: Kiveton Park Coal Co. Managing Partner: Mr Thomas Carrington.

This colliery has been in operation for 14 years, and the furthest workings are now 1½ miles from the shaft. At Kiveton Park, there are two pits 200 fathoms deep, one of which is a downcast and the other an upcast, each 13ft. clear diameter. The downcast alone is used for winding, and is fitted with wire rope guides and double decked cages. There is a pair of horizontal high pressure engines, 36in. cylinders, 6ft. stroke, and the output is 1100 tons in one shift of 10 hours. The other pit is kept for a furnace pit. There are rope slides in it, and in case of an emergency, the haulage engine is ready to wind men; but no coals are drawn. An endless rope, which drives the haulage underground, goes down this shaft and round one of Fowler's clip pulleys at the bottom on an upright shaft, where there are two other pulleys of the same kind worked by clutches, and driving endless ropes to other districts. The tubs are drawn by double forks fixed into the ends of the tubs, the higher catch enabling

the tub to be loaded high, and the lower catch carrying the rope with the empty tub. (See sketch, fig. 6).

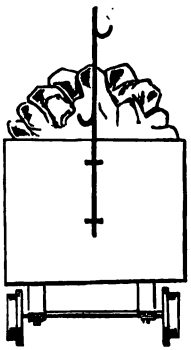


FIG. 6.—KIVETON PARK—MODE OF ATTACHING ROPE TO TUBS.

The seam worked is the Barnsley or top hard coal, which is here 5ft. 4in. thick, a little harder than at Lundhill, and is used chiefly as a steam coal. The seam rises to the west at an inclination of 1 in 22. The workings are by the long-wall method, with the roads going to the rise. The hutches are brought down with snibbles. One of the roads is made a "jinney" or self-acting incline, and levels from it cut off the old roads every 200 yards. The roads are 60 yards apart, and plates are put at each roadhead and the rails laid along the face. The plan, Plate V., shews a portion of the face, the whole length of which is 1400 yards. In the sample

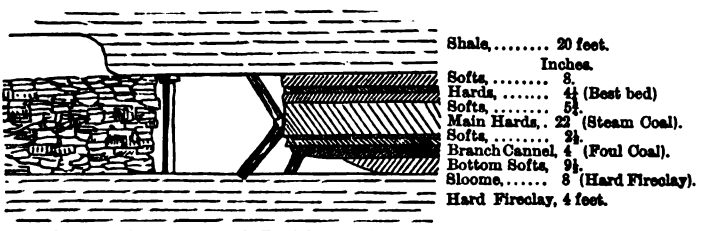


FIG. 7.—KIVETON PARK—BARNSLEY SEAM, SHEWING SPRAGS AND "COCKERMEGS."

place, the working was 5ft. 4in. high. (See sketch, fig. 7.) Above this were 20 feet of strong bind, 2 feet of which was brushed in the roads. Above this was a bed of black rock 6ft. thick. The floor was 4ft. of hard "clunch" or fireclay, and below this was bind. In

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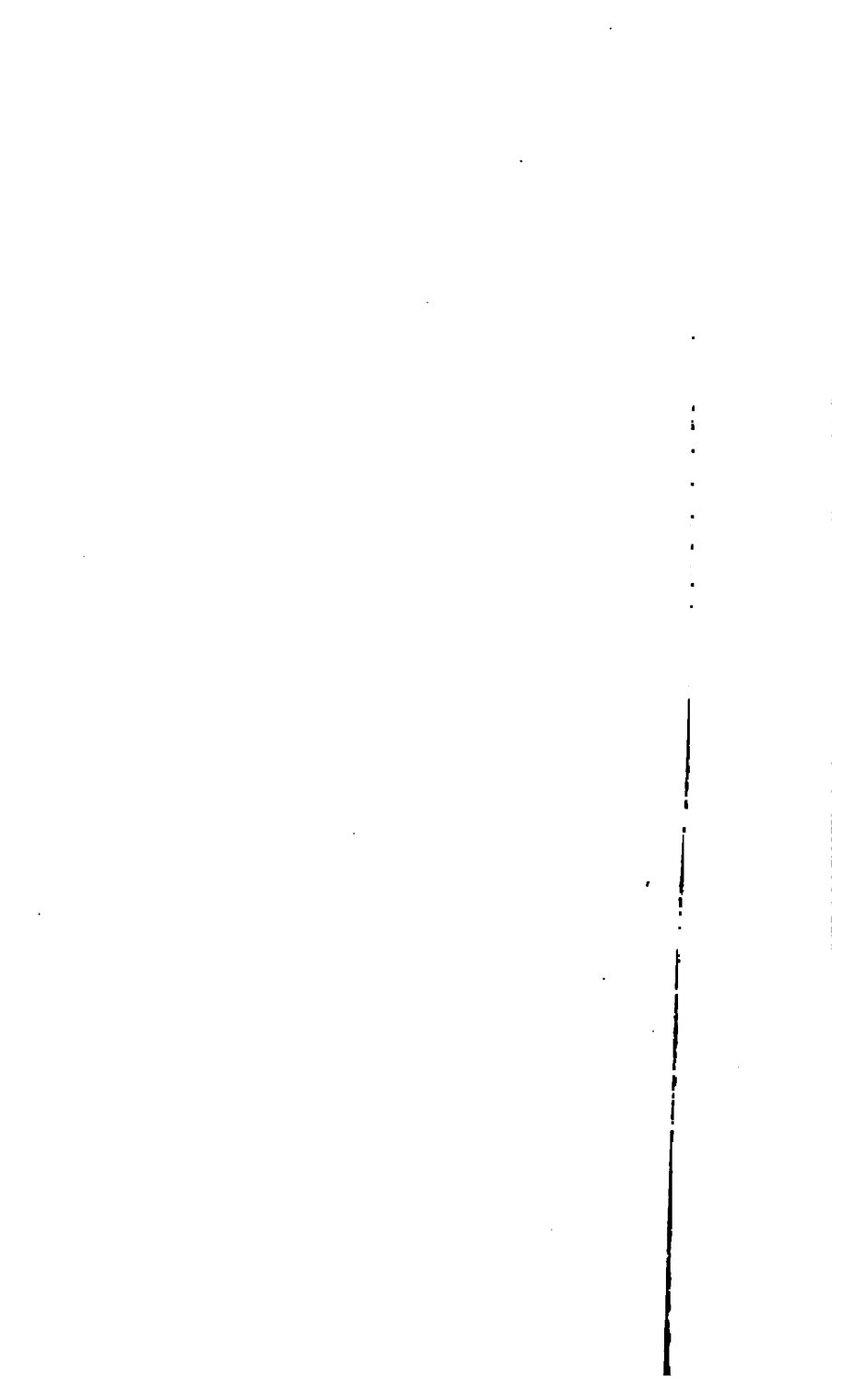


this stall or wall of 60 yards there were two stall men or small contractors who employed all the men and delivered all the coal at the top of the "jinney" for so much a ton. They do the packing, the timbering, and the ripping at the gate roads. Pack walls 6 feet wide are built with the brushing on both sides of the road, which is 10 feet wide, and others parallel to these are built in the waste from the dirt holing and fallen stones. The system is similar to that at High Park. (See fig. 14.) There are two rows of 6in. timber, 6 feet between each row, and 6 feet apart, carried along the face behind the rails. The rear row is taken out as soon as the pack walls are built, and advanced as the face goes on. The roof fell in the waste as the trees were withdrawn. The stallman have the entire charge of the place, but they must put in pack walls and props as required by the deputy. They begin at their road head and hole along both sides of their wall. They hole 5 feet under, 18in. high in front, and put in sprags every 6 feet. (See fig. 7.) Where the coal is tender, what are called "Cockermegs" are put in. (See fig. 7 Section.) These consist of a prop reaching from the floor to the middle, upon which is placed a prop horizontally along the face, upon which is a short prop reaching to the roof. When the coal is holed and standing on sprags a cut in is made at the road head, and a portion of the coal is taken down by taking out one or two sprags. When this is filled, other sprags are taken out, and this is continued on both sides until the extremities of the stall are reached, the rails being laid as the coal is dropped in front. When a holer has gone to the end of his "bank," he comes back and begins another holing at the centre where the coal has been taken away. The stallmen had two fillers and one holer, so that there were five men putting out from 20 to 25 tons a day in the 60 yards of wall. This was a spiendid roof, and there was no timber in the roads. The cost for timber was 2d to 2½d a ton.

Tuesday, 5th April, 1881.—LUNDHILL COLLIERY, near Barnsley. Owners: Messrs Lundhill Coal Company. Manager: Mr John Robinson.

This colliery has been in operation under the present company since June, 1854, and at present operations are confined to three

pits, one of which is used solely as an upcast. They are round pits, the two downcasts are 11½ feet and 12 feet diameter, and the upcast 14 feet 6 inches in diameter, and all of them 107 fathoms deep. The winding pits have pairs of horizontal high pressure winding engines, 25ins. cylinder, 5 feet stroke, 14 feet 6 inches drum, and the output is 750 tons in one shift of 9½ hours. The ventilation is caused by a furnace having a grate surface of 144 square feet, with a dumb drift entering the shaft 35 yards from the bottom, and the quantity of air passing up the upcast shaft is 300,000 cubic feet per minute. This includes 50,000 cubic feet of air which ventilates the stables and feeds the furnaces.

The only seam worked is the Barnsley or Top Hard Coal, which is 7 feet 10 inches thick, and is partly steam and partly house coal. The mode of working is by bord and pillar, the pillars being 40 yards square and both "bords" and "endings" 6 feet wide. In the portion of the working plan shewn on Plate VI., it will be seen that pairs of drifts are driven on both sides of a block of coal 150 yards wide, and after these have reached a given distance this pillar is broken up into stoops and worked back, but only one line of stoops is formed in advance of the line of stooping. The endings are not exactly opposite, but the one is 3 feet past the other to enable the rails to be turned into each working place. The workings are dry and the roads are a little dusty, and are watered at irregular intervals. The roads stand without timber.

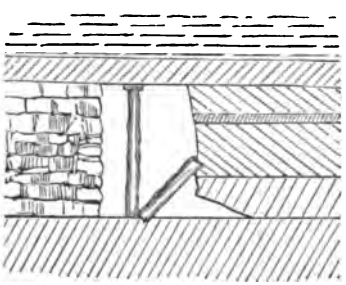
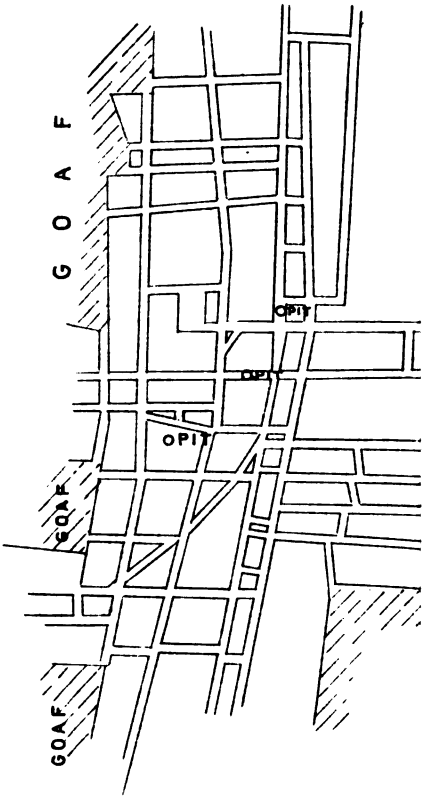


FIG. 8.—LUNDHILL—BARNSLEY SEAM—MODE OF SPRAGGING AND PROPPING IN PILLAR WORKINGS.

In the sample places the working was 6 feet 8 inches thick as shewn on section fig. 8. The roof was 20 yards of shale or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"stone bind," but 14ins. of coal called "top bags" was left on to support the roof, but was taken down in the pillar working. The pavement was 3 feet 6 inches of fireclay with bands, and below this was sandstone 7 yards.

The sample place of solid workings was a room 6 feet wide 20 yards up. There were no props in it except for carrying the wooden brattice, which was made in lengths of 10 feet and 4 feet broad, overlapping in the centre and nailed to light uprights. It was kept within 12 feet of the face, and divided the place into an intake on the dip side 4 feet wide, and a return on the rise 2 feet wide. There were two men in the place—a holer and a filler. The method of working (see

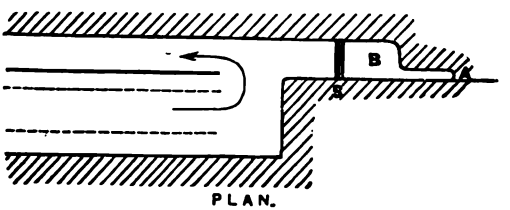


FIG. 9.—LUNDHILL—BARNSLEY BED.

FIG. 10.—MODE OF WORKING IN SOLID PLACES.
(Scale—1 inch = 10 feet.)

sketch figs. 9 and 10) is for the holer to cut a shearing (A) 6 inches wide about 18 inches form the rise side of the place. When he has cut this shearing as far as he conveniently can (about a yard), he wedges off the 18 inches of coal (B) on the top side to enable him to get further in with his shearing, leaving

t to the filler to hole and work off the coal. A sprag (S) is put in to protect the man shearing while the filler is holing. When we saw it the 6 inch shearing was 9 feet in advance, and the 2 feet wide portion 3 feet behind the face of the shearing. The men were paid yardage, at the rate of 5s a yard, in addition to the ordinary working price of 11s 11d for ten tons of coal.

The pillars are worked off in lifts of 8 yards. These lifts are generally driven up the whole length of the pillar, but if more coal is required, men are sometimes put on the other side of the pillar to work downhill and meet the lift coming

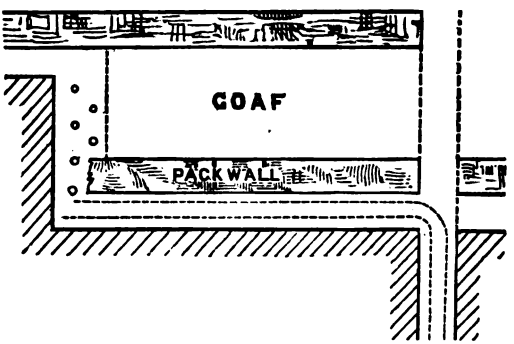


FIG. 11.—LUNDHILL—BARNSLEY BED—MODE OF WORKING OFF PILLARS.
(Scale—1 inch = 33 feet.)

up. In the sample place, (see sketch, fig. 11) one lift had been taken off the whole length and a second was up 20 yards. The roadway was carried up along the coal and was 6 feet wide. On the waste side of the road was a pack-wall 6 feet wide at bottom and 5 feet at top, built with the 6 inches of clay seam and debris from the waste. There were two rows of props kept next the face in addition to this building, the one row was three feet in front of the other and the props were 6 feet apart, the rear row breaking band. These props were 6 inches diameter, and were set with hard wood lids 8 inches square by 2 inches thick. The building is added to every three feet and the rear row of props advanced. When the rear row of props is removed the top coal falls and as much of it as can be removed is

taken. Two colliers worked at this face. They hew and fill the coal and put in the props, and for doing this are paid 11s 11d per score of 10 tons. They hole 3 feet in, a foot high in front, and put in sprags every 6 feet. (See sketch fig. 8.) After the holing is finished they knock out the sprags and the coal comes down. There is no powder used either in the solid places or pillar workings. The coals are riddled through a ¾ inch riddle, and the whole of the dross is thrown into the waste. The buildings are carried on by a special class of men called day-men or packers, who also draw the props, and for doing so are paid 4s 4d

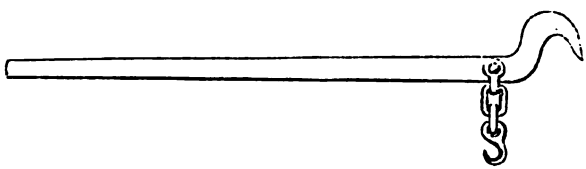


FIG. 12.—"DOG" USED FOR DRAWING PROPS.

per day. The props are drawn with what is called a "dog and chain." The "dog" (see fig. 12) is an iron bar 3 feet long, and 5ins. from the end there is a chain with two links and a hook about 6 inches long. A piece of half-inch long linked chain 6 feet long, with a hook at the end of it, is passed round the prop and hooked into a link. The other end of it is put into the link of the "dog." The point of the lever is pressed against another prop as a fulcrum and the prop drawn out. Before beginning to pull the prop, the man drawing it cuts the roof coal round the top of the tree so as to make it come more easily. When the props are drawn out the roof falls quickly; but there were no props or gears in the roadway. The rails were not turned along the face but the coals were cast up to the road head. Instead of employing two sets of men it sometimes happened that the same men worked the coal and put up the packwalls, and for this they were paid 3½d a ton in addition to the scorage price.

The 14 inches of coal on the top made a really good roof, both for the roads and faces—the shale was only exposed in the waste.

The special rules as to propping are :—

7.—The manager shall see that an ample supply of timber, props, sprags, &c., is always on the premises, and the underviewer shall see that the same are distributed, and also report any deficiency. The underviewer or his deputy shall see that the roof and sides in all working places are properly secured by the persons working in them, and that the roof and sides of every travelling road be made and kept secure.

26.—The deputy shall see that the timber is properly distributed; that there is sufficient; and that it is used when necessary for security.

37.—The stallman in charge of each stall shall, under the direction of the underviewer or his deputy, set a sufficient quantity of props and bars for safely supporting the roof and sides in his working place. The timber shall be properly set and be removed and renewed as often as is necessary.

38.—The stallman shall set or see that sufficient sprags be set not more than every two yards apart before beginning to hole, and the stallman shall always leave the stall in a safe state when leaving work.

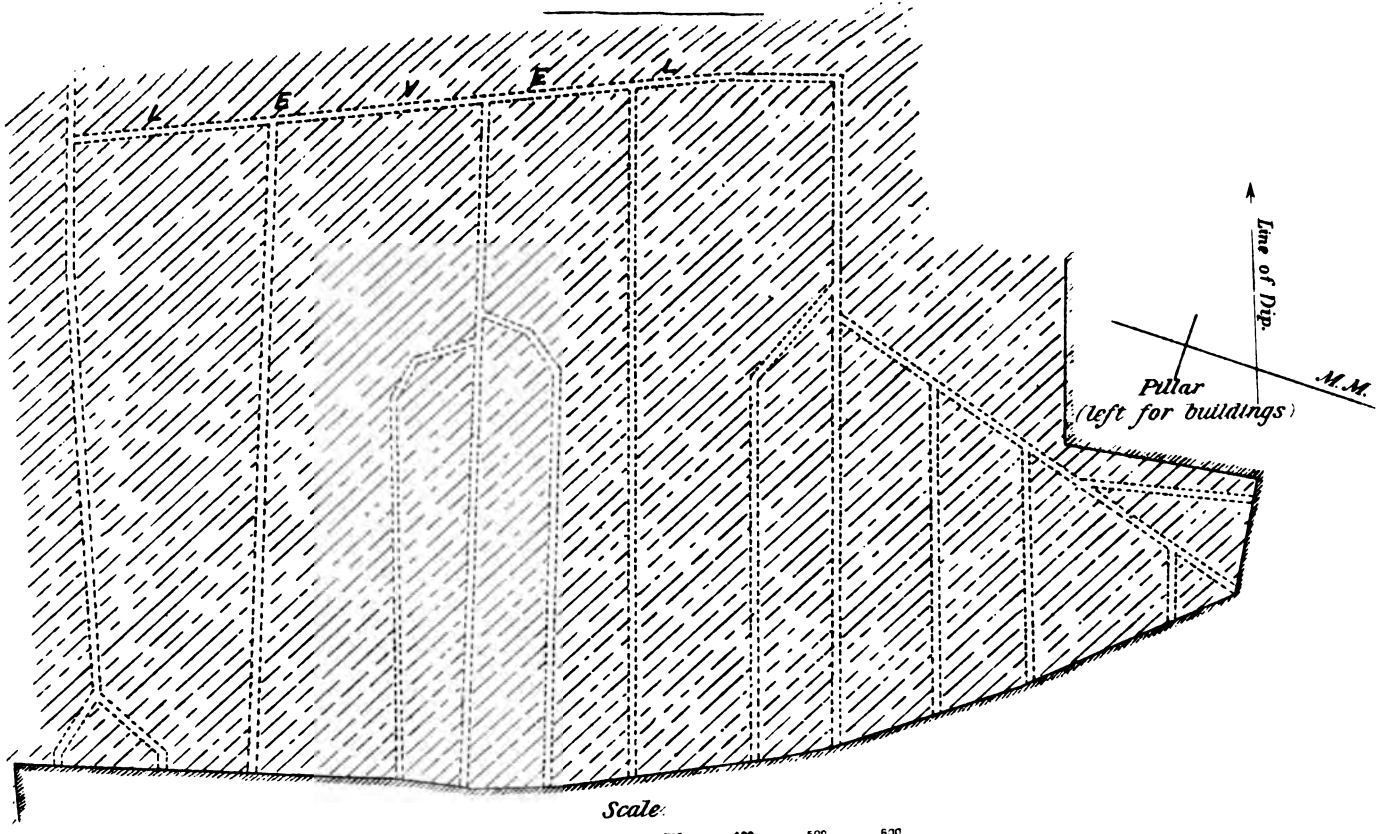
HIGH PARK COLLIERY, Langley Mills, Notts. Owners: Messrs Barber, Walker, & Co. Agent: Mr R. Harrison. Manager: Mr Wm. Weston.

This colliery has been in operation for twenty years and works the Top Hard coal, at a depth of 100 fathoms, by twin pits, one engine drawing from both. They are both downcasts. They are circular and 10 feet in diameter, with one cage in each carrying two trams or hutches, each holding 11 cwt. The output is about 900 tons a-day, and this is all picked and lifted from the hutches to the waggons by hand, no screens being used. The upcast pit is situated 1100 yards on the "basset" or rise of the measures, is

PLAN OF PART OF HIGH PARK COLLIERY.

Reduced from Working Plan.

PLATE VII



12 feet in diameter and 58 fathoms deep. There are two upcasts together, each for a separate colliery, and with a Waddle fan 30 feet in diameter on each so placed that if the one break down the other fan can draw the air from both pits. The fans run 70 revolutions per minute.

The seam is 5 feet 2 inches thick, and rises at an inclination of 1 in 22. The workings are by the long-wall method—see plan, Plate VII.—and there are 48 stalls all in line for an output of 900 tons—the distance from centre to centre of the gate roads being 50 yards. The roads go up hill and are cut off every 400 yards by a cross-cut from one of the roads which is made a "jinney" or self-acting incline, and all the

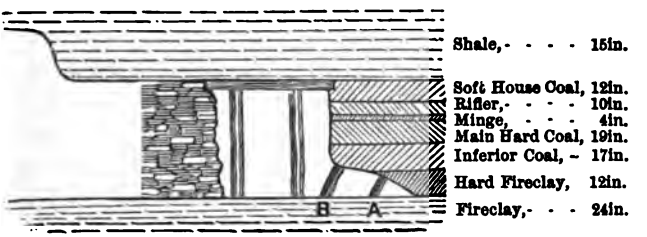


FIG. 13.—HIGH PARK—TOP HARD COAL.—MODE OF PROPPING AND SPRAGGING COAL.

coals are sent down by it. In the sample place the working was 6 feet 2 inches thick. (See section, fig. 13). The roof was 15 feet of shale, 3 feet of which were taken down in the roads. Above this was a thin bed of coal 2 feet 6 inches thick, and above this is "bind" or shale. The pavement is 2 feet of fireclay, and below this is dark sandstone. In each stall are three stall men who contract for hand filled coal at 1s 9d a ton, all the dross being stowed. They employ loaders and holers and do all the work in the place, brushing and building the first ripping three feet, and draw the coal to the first pass bye, which is never more than 50 yards from the face, From this point they are drawn by a pony to the head of the incline or "jinney," and thence by a rope haulage to the shaft.

The packs are within 4 feet of the face when a holing is begun, and there is a row of 8 inch props, 4 feet 6 inches apart along the face. (See fig. 14). The props are 5 feet 3 inches long, of Norway timber, and have lids made from broken props 12 ins. × 4ins. × 6ins., and are put in by the stall men. The place being in this condition, the holers begin at the centre and go on holing to both sides, putting in sprags (B. fig. 13) 2 feet long every 6 feet. Where necessary short sprags (A. fig. 13) about 15 inches long are put in underneath the coal, but there is no fixed distance which they should be apart. The holer holes 4 feet in, and for doing so the stall-man pays him 1s 6d a fathom. The rates for holing are 1s a fathom 3 feet in, 1s 6d a fathom, 4 feet in, and 2s for 5 feet. The stall-man, however, only requires the holer to hole 4 feet in, and then after this has stood a short time and the fireclay has been crushed he himself holes it the other foot in. While the coal is standing on sprags a shearing is made at the roadhead, 2 feet wide at the outside and tapering to 3 inches about 5 feet in. After this is done the stallman begins by taking out three or four sprags, and allows the coal they supported to fall. This is filled and the roadway laid along the face (see fig. 14), props and gears being set up over the rails

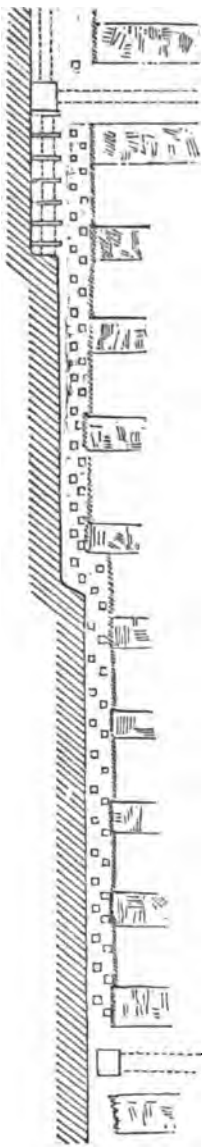


FIG. 14.—HIGH PARK COLLIERY—SKETCH SHEWING PART OF TWO STALLS WITH THE PACKWALLS. (Scale—1 inch = 33 feet).

about every 4 feet 6 inches. The one end of the "bar" or crown is let into the coal some 3 or 4 inches, and the other supported on a prop. The props are 6 to 8 inches in diameter, and 5 feet 3 inches long. The crowns are 5 inches by 4 inches, and 4 feet long. When this is done other sprags are taken out and the coal filled, and the process is repeated until the end of the stall is reached on both sides. There are two rows of props about 5 feet apart behind the props and gears before the packs are shifted forward. These props are taken out by the stallman when he builds the packs. The roof in the district visited being tender and in places much broken, packs are built of the debris from the roof, about 6 feet wide, at distances of 9 feet between them.

There are deputies in the pit who superintend the stallmen and do the duties of firemen in Scotland, examining the places for fire-damp, &c., but the stallmen set and draw all the timber and brush the roads. The working is carried on with naked lights, but a safety lamp is fastened in the highest part of the brushing so as to give warning when there is any fire-damp. The brushing is blasted.

There are very few props in the main roads, as they sink very quickly, and the main levels soon require to be brushed up to the thin bed of coal, which makes a good roof. The extreme subsidence takes place 50 yards back from the face. The roads are dusty and are watered at irregular intervals.

NORTH STAFFORDSHIRE DISTRICT OF INSPECTION.

The special rules as to propping are :—

45.—Every workman shall secure the roof of the place where he may work by props or other means, and shall set sprags whilst holing at distances never more than six feet apart, and oftener if necessary, and if, upon application to the overman, underlooker, or bailiff, or fireman, he shall not be provided with sufficient props for that purpose, he is to cease working, and report the same at the Colliery office, and in case of his complaint

being substantiated he shall be paid for his time lost by so doing: but this rule shall in no way relieve any person from any obligation prescribed by any general or special rule.

16.—Every Overman or Fireman shall see that so far as is reasonably practicable that the travelling roads and working places of the men are secured with props or otherwise . . . that sufficient props be provided, and that they be set, drawn, and removed, at the proper time, and shall cause sprags to be set whilst men are holing, in no case to exceed six feet apart, but oftener when near a loose end or tender coal.

5.—The Underlooker or Bailiff, or if no Underlooker or Bailiff, the Manager shall see that the travelling roads and working places in the pit are in all cases made secure in accordance with sec. 51, gen. rule 16.

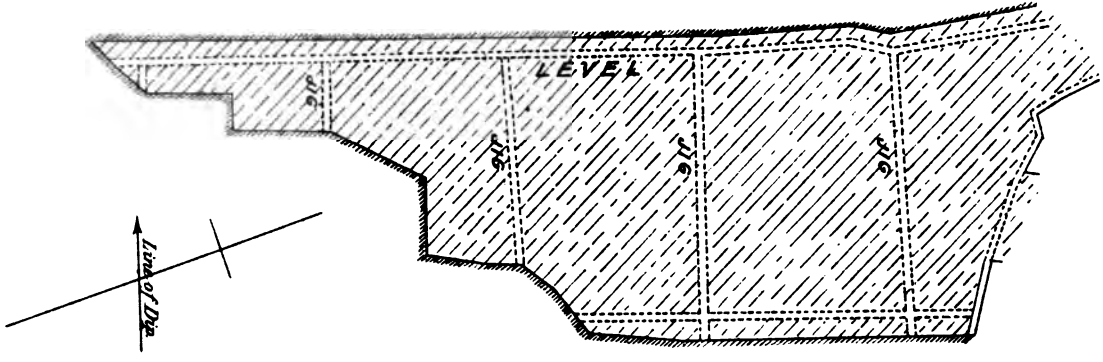
Thursday, 7th April, 1881.—FLORENCE COLLIERY, Longton. Owner: Duke of Sutherland. Agent: Mr Chas. Bromley.

This is quite a new colliery and works the Great Row Seam (the same as at Great Fenton) at a depth of 176 fathoms. There are two pits, one 12½ feet and one 14 feet diameter, one of which is the downcast and the other the upcast. The downcast is sunk 373 fathoms to the Moss Coal, which is the best House Fire Coal of the series, and the upcast is in course of being sunk to the same seam. The downcast is the winding pit, and on it there is a pair of high-pressure horizontal winding engines, 42 inch cylinder, 7 feet stroke, with double beat valves, and a 28 feet cylindrical drum. There is an automatic cut off on the engine to stop the cage when it reaches the surface, but it is not at present in operation. The Bassey, Chalky, and Ash Seams are also worked—the cages stopping at each seam. The ventilation is caused by the exhaust steam from a pumping engine placed 75 fathoms down the upcast shaft. This is only a temporary expedient, as a 45 feet Waddle Fan is in course of erection.

The seam rises at an inclination of 1 in 7. The workings are by the Long-wall method. (See plan, Plate VIII). Two levels, 10 yards apart, were driven from the pit bottom for a distance of 350 yards, and at this point a "breasting" of 25 yards of coal was taken

PLAN OF PART OF FLORENCE COLLIERY.

Reduced from Working Plan.



Scale.

100 50 0 100 200 300 400 500 600

Feet. Feet.

out with a "gob" road in it, and about 4 yards of building on the deep side. The walls are broken off from this and are 88 yards wide with a road up the centre. These roads are cut off by a level every 120 yards. The faces are not all in line, but some are "stepped," the one being 15 or 20 yards before the other. There is a "jig" or self-acting incline in each road and the coal is brought down by this to the level. It is drawn along the main level by horses.

There is a very simple wheel in use here for the self-acting inclines, for bringing down the coals from the face. It is a 12-inch wheel put into a fork. This is put through a tree at the road-head. The brake consists of a piece of iron which is pressed down on the rim of the wheel by a handle working a dumb screw fastened to the fork. One hutch, holding 8 cwts., is run down at a time and the brake is just sufficient to stop it. In the place where we saw it working the chain slipped round the pulley*, but it was sufficiently retarded to stop the hutch.

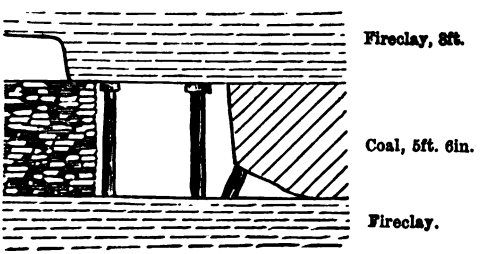


FIG. 15.—FLORENCE—GREAT ROW SEAM—SECTION SHEWING MODE OF PROPPING AND SPRAGGING AT FACE.

In the face of the level the working was 5 feet 6 inches thick. (See section, fig 15). The average thickness of the seam throughout the pit was 6 feet. The roof was 8 feet of fireclay and above this was a bed of coal 2 feet 6 inches thick. Lying on the top of this coal were beds of fireclay and bass (hard dark shale) 8 feet thick, then coal and partings 8 feet, and then 32 feet of "Binds, Slums, and Marls." The floor was 37 feet of "Bass, Binds, and Clod." The "breasting" or face was 25 yards wide and was kept in

*NOTE.—This is easily stopped by a small brake stick.

advance for opening up fresh roads. There was a 3 yards building kept on each side of the road, which was 6 feet wide. There were two rows of timber in when we saw it, a row of 6-inch props between the rails and the face, with the props 5½ to 6 feet apart and 4 feet 6 inches between the rows. The props had lids made of broken props when sufficient for the purpose. New buildings are put in every 5 feet and the rear row of props advanced. There were sprags under the coal every 6 feet. The space between the building and the ribside is kept open as long as possible, and when this can no longer easily be done a hole is driven through the building and a fresh aircourse kept up from this point. There is a chock made of broken timbers put up at the corner of each hole. These holes are made about every 40 yards.

The common walls or stalls are 88 yards wide, and 3 yards packs are built parallel to the road 7 yards apart all the way

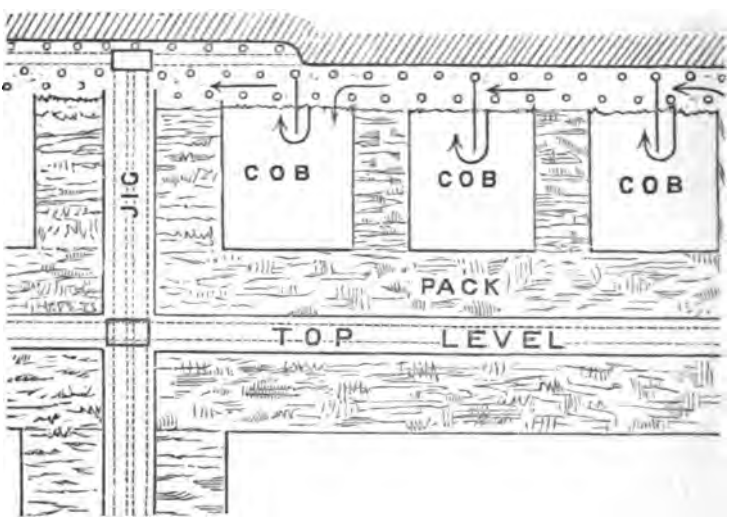


FIG. 16.—SKETCH, SHEWING PART OF A LONGWALL FACE WITH THE GATE ROAD AND PACKWALLS.
(Scale—1 inch = 33 feet).

through. (See sketch, fig. 16). Those next the road were 4 yards wide, and were built with stones from 3 feet of brushing or top ripping taken down in the roads. In each stall of 88 yards there

were two stall-men, one for each side of the road. They employed 4 holers, 2 buttockers, and 2 packers, and paid them each 3s 7d for a certain amount of work done. The stall men draw the timber, make the packs, and send the coals down the incline to the level, and are paid 15s per score of tubs of coal,—7s being allowed for slack,—all of which is raised. The men rake the coal into iron trays 2 feet square and 6 inches deep at the one end, tapering out at the other. These have two handles by which they are lifted and emptied into the tub. The output of one of these stalls is 100 tubs holding 8 cwt. each per day of one shift. In addition to the price already mentioned, the stall-man is paid 5s 6d a yard for top ripping and packing the stones into the buildings. Any other stones required for buildings are drawn out of the waste. The coal was holed 4 feet in, 2 feet high in front, and sprags were put in by the holer every 6 feet. (See sketch, fig. 15). These sprags are 2 feet long and 6 inches diameter. After the holing is completed, the sprags are knocked out and the coal blown down with powder. The shots are fired by the stallmen. The coal is dropped in advance of where the rails are laid, but for convenience of filling the rails are kept pretty close up to the "buttock" or piece of coal next to be taken down, and advanced with it. The holers do not remove from side to side as coals are being dropped, but if a shot has to be fired on any one side those working there remove to a safe place until the shot has been fired, when the work goes on as before. The props are 5½ to 6 inches diameter at the thin end, and there are two rows 4 feet 6 inches apart with the props in each row 6 feet apart. These are put in by the stall-man and drawn out by him with a dog and chain. The pack walls are built on every 5 feet. If the roof is tender a chock made of broken timber and built on small coal is put in. There is a sheet put in from the face for some feet back the wastes between the packs and the air is made to travel back into the goaf. The place is worked with safety lamps and there is a fireman who examines the lamps and whose orders the stall-man must obey, but he does not do anything to the timber.

In the main roads, which are now being driven in the gob, there is but little timber, but in the road where the pillars are standing there is a great deal of side pressure and a good deal of timber

This is notched in the Welsh fashion (fig. 28). The uprights are 8 inches at top and 7 inches at bottom, 6½ feet long and notched so as fit into an 8-inch crown which is also notched. These are put 3 to 4 feet apart, and there are 3-inch props put from crown to crown and laggins laid across these. In putting up these gears there are two men employed. The timber is notched before being brought down the pit. One prop is put in place and an iron bar with prongs at both ends called a dog is put up to steady it. The other prop is then put up and the crown put on. Then the whole is struck up tight with a hammer. We noted several contrivances for repairing gears, which we thought worth while describing. In one instance there was a set of timber which

FIG. 17.—TIMBERING IN MAIN ROAD AT FLORENCE COLLIERY.

might be described as an upright "cocker" (fig. 17). The uprights were 5 feet 6 inches apart at bottom and 4 feet 6 inches at top, and the rise of the span was 8 inches. Where the crown of the Welsh timbering was broken, a diagonal strut was notched in

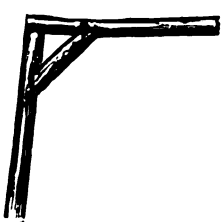


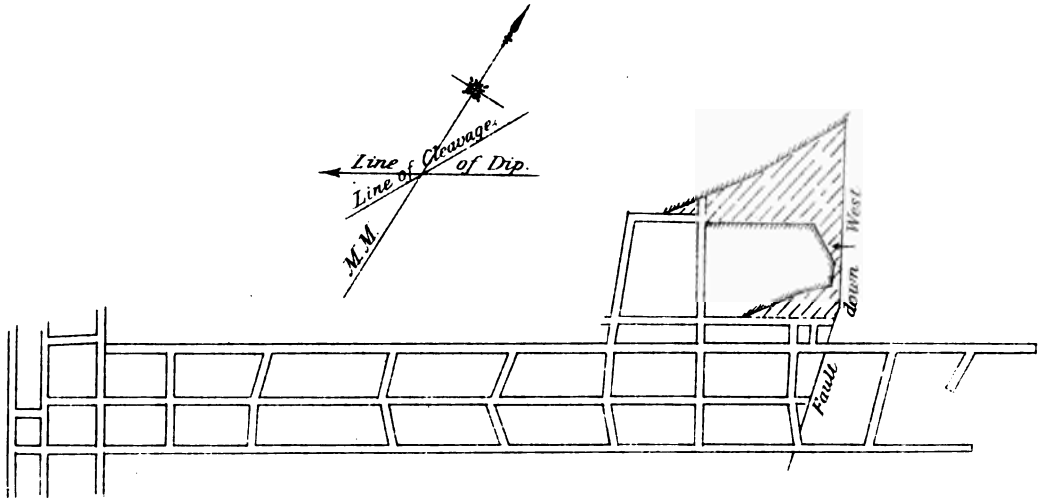
FIG. 18.—METHOD OF REPAIRING BROKEN CROWN OF WELSH TIMBERING, FLORENCE COLLIERY.

FIG. 19.—METHOD OF REPAIRING BROKEN CROWN, FLORENCE COLLIERY.

the side of the prop and the gear as sketched (fig. 18). In another

PLAN OF PART OF GREAT FENTON COLLIERY.

Reduced from Working Plan.



case where the gear had been put into the coal a piece was cut out and a short strut was put up to the point of fracture and wedged tightly to the crown (see fig. 19). The roads are very dusty, but are not watered as the pavement would rise. The roof of this seam was very soft and loose and yet the quantity of timber was not very large.

GREAT FENTON COLLIERIES, Stoke-upon-Trent—Owners, Messrs Stafford Coal & Iron Co. (Lt.); Manager, Mr T. Nichols.

This colliery consists of four pits, two of which, the Pender and the Bourne, have been in operation for the last five years, and work the Blackband Ironstone and the Great Row Coal Seam; the other two, the Homer and Sutherland, are new pits, and are sunk to the Ash Coal and Littlemine Ironstone. There is about quarter of a mile between the pits. The Pender and Bourne Pits are 13 feet and 8 feet diameter respectively, and 154 fathoms to the Great Row Coal. The Pender pit is a furnace pit, and has wire rope slides in it, two ropes for each cage, both of them being on the outside. There are fifteen inches between the cages at meetings. There is a vertical winding engine, 36 inch cylinder, 6 feet stroke, and 20 feet drum. The output is about 500 tons a-day.

The seam rises at an inclination of 1 in 10, and the workings are by the long-wall method, with 100 yards between the roads. The plan, Plate IX., shews the workings in a district which is just being opened out. In the sample place the working

was 6 feet high and there were 3 feet of coal for a roof. (See sketch, fig. 20.) Above this there were 5 yards of moderately strong shale, above which was a bed of coal, 7 inches thick, and on the

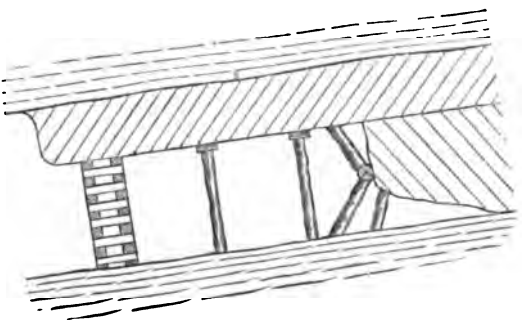


FIG. 20.—GREAT FENTON—SECTION OF FACE SHOWING COCKERSPRAG, SPRAG, PROPS, AND CHOCKS.

top of this was shale. This thin coal gave off a good deal of fire-damp. The pavement consisted of hard "sagger" or fireclay, 4 feet thick, and below this was grey metal.

A contractor, called a "Butty" contracts for a certain sum per ton or score to put the coal into the waggons at the surface. He is furnished with all the materials by the owner, and supplies all the labour. In a face of 100 yards he has 9 or 10 holers, 4 loaders, and 2 buttockers, who break out the coal for the fillers. It is the buttocker's duty to take out the sprags and let the coal fall. There are four packers for building the packs. The butty has a man specially appointed to take charge of the timber. The holers set their own props and keep themselves safe, but the butty's man sets the chocks and draws all the wood. The holers and the packers work at night, but the fillers work during the day while the pit is drawing coals (from 6 a.m. to 3 p.m.) The coal is blasted, but the shots are not fired till after 10 o'clock p.m. The roads are 3 yards wide, and there are 4 yards buildings called

packs on each side (see fig. 21). Besides these, there are buildings or packs, 4 yards wide, parallel to the roads every 8 yards, the space between being open. These packs are built from the fallen stones got from the cundies, there being no brushing. Be-

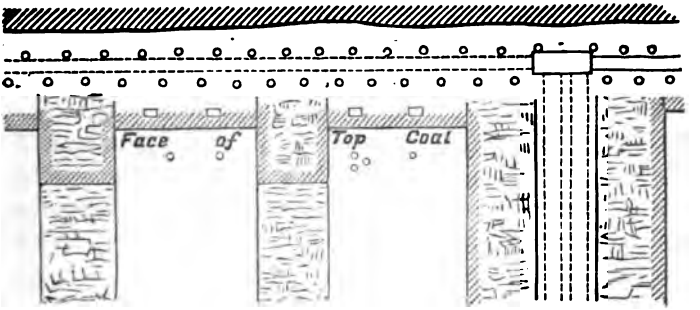


FIG. 21.—GREAT FENTON PLAN OF FACE, SHEWING PROPS AND CHOCKS.
(Scale—1 inch = 33 feet.)

fore the holing is begun cockersprags (see sketch, fig. 21) formed of two 3-feet props, and an old 6-feet prop, are placed all along the face. The coal is then holed 5 feet under, and sprags are put in under the coal every 6 feet in addition to the cockersprags, and in compliance with the Special Rules the packs are kept built up to within 6 feet of the face, but between them and the face, and parallel to it, are kept two rows of 8-inch props, 6 feet apart, and 4ft. 6in. between the rows. The rails run in between these props. In each waste, between the packwalls, there are two rows of timbering, 6 feet apart, up to the head coal, each line consisting of three props and a chock. The miner shears the head coal, which is supported by these props, takes out the timber, and the coal falls. After this is done, props are put up to the roof from the top of the rubbish, with a lid and a sole, and the miner takes out the head coal over the packs. This he does by holing in on the 4-yards packs, for 2 yards on each side, and allowing the coal to drop. The whole of the coal over the packs is not got, but only as much as can be got without running risk

from the roof. The trees are then withdrawn with a "dog and chain" by the man appointed for the purpose, and the roof breaks down, the chocks preventing it from coming over the face. The roof coal is not taken down over the roads, nor the packs on each side of the road. As the roof sinks, however, this is brushed up in the coal, and left in an arched form, and in this way requires very little timber.

There is no particular system of putting in timber in the main roads, and it is put up only where it is required. The trees used are 8 inches diameter, and have a lid 6in. by 5in. and 2ft. 6in. long. In one of the main roads there were 7in. crowns, notched into the coal on the one side, and with short 3ft. props resting on the coal on the other. The roads were dusty, and were watered when required. The roof was a good, safe one, requiring little timber.

SOUTH STAFFORDSHIRE DISTRICT OF INSPECTION.

The Special Rules as to Propping are:—

2. The Manager shall adopt a uniform system of timber propping at stated distances in the pits under his charge, where the condition of the mine, or any part thereof, in his judgment, requires it.

5. The Overman or "chartermaster" shall see that a plentiful supply of timber, for props and other purposes, required by the workmen to carry on their operations with safety to themselves, is always ready near to the entrance of the mine, and he shall see that the same is conveyed to the places for which it is required.

6.—He shall see that the miners attend to the security of the roofs and sides of the working places; and if any miner fails so to secure his working place by propping the same, or otherwise, he shall point out to such miner any such failure, and should

such miner refuse, or fail to perform such repairs as are necessary to render the place secure, he shall require him and his assistants to remove from such working place.

12.—If the fireman shall encounter falls from the roof in any of the roads which he is required to traverse, or in working places under the care of the miners, he shall at once send workmen to remove the fall and secure the roof, and report the same to the manager or overman, and until this shall be done, no miner or other workman shall be allowed to proceed near or under the broken roof, except such workmen as are employed to repair the same.

13.—He shall examine the roofs and sides of the roads, and faces of the working places, and prevent miners or other workmen entering the roads or working places until a report shall be made that they are safe.

14.—He is to report to the overman or manager . . . (6) any failure to make secure the roof and sides of travelling roads and working places, under General Rule 16.

16.—Stallmen and contractors shall strictly obey the instructions of the manager or overman in making secure the roofs and sides of their roads and working places, and they shall see that the miners in their employ securely sprag and prop their working-faces, setting sprags not more than six feet apart, and nearer when necessary. One at least of the stallmen shall remain in charge of his stall until the day's work is done.

24.—The miners shall build their cogs of such dimensions and at such distances apart as the manager or overman shall from time to time direct.

25.—If from accident, or any other cause, miners are at any time unable to find a sufficient supply of prop-wood at the place appointed, when it is unsafe to contine their work without it, they are expressly forbidden to remain at their working places.

45.—If the miners or other workmen, in proceeding to their working places, or in travelling along any road, or other part of the works, shall meet with or see any fall from the roofs, or shall observe any dangerous place in the roofs, walls, or elsewhere, they

shall instantly report the occurrence to the manager, overman, or fireman, and shall not pass the fall or dangerous place until the same shall have been made secure.

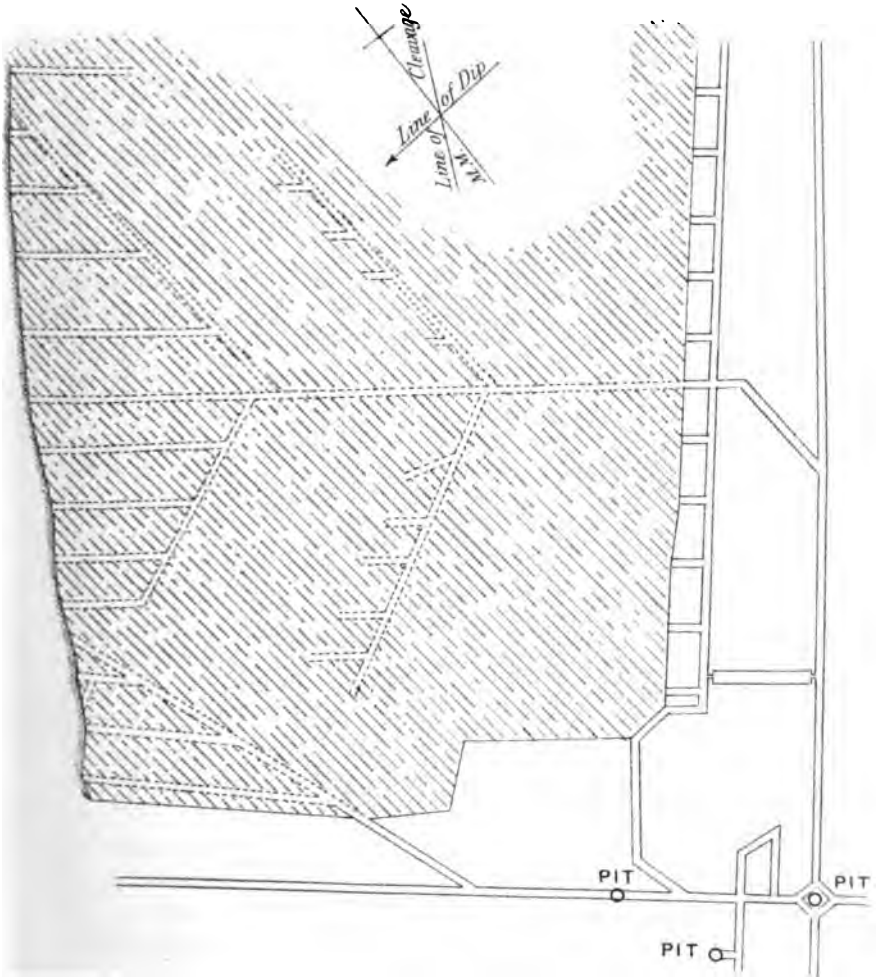
Friday, 8th April, 1881.—CANNOCK AND RUGELEY COLLIERY, HEDNESFORD.—Owners: Cannock and Rugeley Coal Co. (Limited). Agent: Mr John Williamson.

This colliery has been worked for 16 years, and at present the workings are in the deep and shallow coals, the former 10 fathoms below the latter. The deep seam is the lowest of the series, and 23 fathoms under this the Silurian measures are got. We visited first the Pool Pits where there are two shafts, each 15 feet diameter, with 70 yards of metal tubbing in each shaft keeping back feeders of water equal to 3000 gallons per minute. The depth to the shallow seam is 163 fathoms, and to the deep seam is 174 fathoms. The winding engines have a pair of horizontal high pressure cylinders 32 inches diameter. Coals are drawn by one shaft, and 4 tubs, holding 13 cwt. each, are raised at a time. The output is about 900 tons a day, but we were informed that 1051 tons had been drawn out of this shaft in 8 hours. The other pit is used as an upcast, and the ventilation is caused by a 40 feet Guibal fan 12 feet wide, which is driven 33 revolutions per minute, and gives 150,000 cubic feet of air per minute, with 1½ inches water gauge.

We did not go down these pits, but went on to the Cannock Wood Pits, which are about 1½ miles distant. There are there three shafts, two downcasts, each 12 feet in diameter, and an upcast 16 feet diameter. All the pits are sunk to the deep seam, and are 100 fathoms to that seam and 89 fathoms to the shallow seam. Only the two downcast shafts wind coal, and the quantity raised is 800 tons per day of 8 hours. The cages hold two tubs, each of which holds 13 cwt. All this coal is hand-picked, the hutches being run alongside the waggons, and the coal is sorted by men into seven different kinds. There are 50 men on the pithead, and they put 800 tons into the waggons. The sorting is contracted for at 3⅞d a ton. The ventilation is caused by a Guibal fan 40 feet diameter and 12 feet

PLAN OF PART OF CAMNOCK WOOD COLLIERIES.

Reduced from Working Plan.



Scale.

Feet. 100 50 0 100 200 300 400 500 600 *Feet.*

broad, with two engines 36 in. cylinder, 36 in. stroke, each of which drives the fan for a month at a time. It is driven at the rate of 36 revolutions per minute, and gives 180,000 cubic feet of air at a water gauge of 1½ inches. The miners work with the Williamson Safety Lamp, but we saw no firedamp, although we were informed that at a borehole put 30 feet into the coal a pressure of 35 lbs. to the square inch of gas was shewn.

The pits are sunk on an anticlinal axis, and the coal dips on both sides at an inclination of from 1 in 24 to 1 in 18. Both the shallow and the deep seams are worked by the long-wall method. The workings in the lower seam are kept 300 yards in advance of the upper. This is found to work better than keeping them in line or working the top seam first. Our underground inspection was confined to the deep seam, which is 6 feet 7 inches thick. A plan of a portion of the workings in this seam is shewn on Plate X., from which it will be seen that the roads are from 30 to 35 yards apart, and cross roads are formed in the gob every 100 yards. In the sample

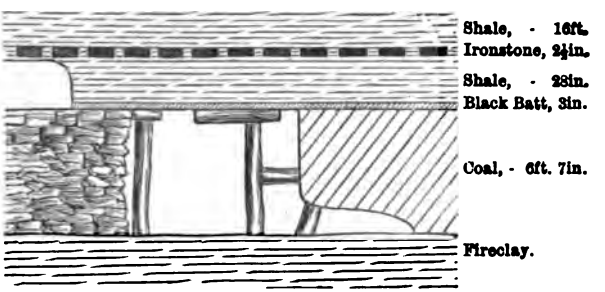


FIG. 22.—CANNOCKWOOD—DEEP SEAM—MODE OF PROPPING AND SPRAGGING.

place, the coal was 6 feet 7 inches thick. (See sketch, fig. 22). On the top of the coal were 3 inches of black batt, above which were 18 feet of dark shale with thin ironstones. Above this were 21 feet of white rock. The floor was fireclay. There were 8 yards buildings on each side of the roads, then there were 5 yards of vacant waste, and then a 6 yards building in the centre. The road was

11 feet wide, with a plate at the roadhead, and the rails were brought up along the face (see fig. 23). In addition to the special rules of the district, the following regulations relative to the distance apart at which props are to be set are issued by the manager :—

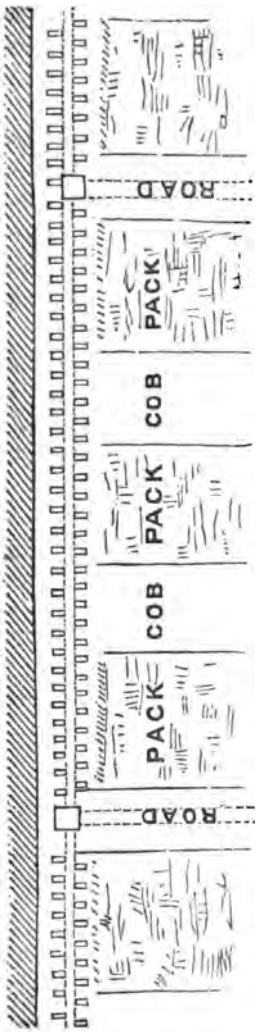


FIG. 23.—CANNOCK WOOD—DEEP SEAM—PLAN OF A STALL, SHEWING PACKS AND PROPS AND ROAD ALONG FACE.
(Scale—1 inch = 33 feet.)

The distance for props to be apart on the face must not exceed 3 feet, and each prop must have a suitable lid on it. The distance between the props for a tram road in between must not exceed 5 feet, and a prop must be set within 4 feet 6 inches of the Buttock of Coal.

The Sprags under the Coal must not exceed 5 feet apart, and they must be well set.

The stallmen or Contractors to see that the timber is set as above, and to see that the workmen employed by them do not work in danger.

The Stallmen or Contractors to examine the way end, and all parts of the stall, and if there is any danger the men must not be allowed to work.

The Chain and Bar must be used in drawing timber. Workmen found endangering their lives by neglecting to use the Chain and Bar, or by not setting timber to secure the Roofs and Sides whilst drawing timber, will be sent out of the mine at once and summoned before the Magistrates.

The Competent Men must see that the timber is set as above, and examine the coal, roof, gob road and wastes of each stall, and if they find any danger to stop the stall, and report the same at once to the Underground Manager. The Underground Manager to go and examine the stall, and if he finds it in a dangerous state for want of the timber not

being properly set, the stall must be stopped until the danger is removed, and the stallmen to be fined not less than the sum of Two Shillings and Sixpence for each offence.

There is a corresponding set of regulations for the shallow seam where the props must not be more than four feet apart along the face, and there must not be more than five feet between the first prop and the building. In the sample place the coal was holed 5½ feet under, and eight inch sprags two feet long were placed under the coal every 4½ feet. There was a row of eight inch props with broken props for lids, set three feet apart two feet back from the face (see fig. 23). From the centre of the prop there was a short eight inch sprag with a lid bearing on the face of the coal. Five feet back from this was another row of props with lids three feet apart, and immediately behind this were the packs. The rails were laid between the two rows of props (see fig. 24). This method of working gives a pretty large proportion of dross, and another way is being commenced. This is called "banicking," and instead of holing in the bottom of the coal they hole for three feet in the shale overlying the coal and break the coal off with crowbars. It breaks off the lines of cleavage and gets into a series of steps. This method is found to give satisfactory results, giving 80 per cent. of round coal. There are short sprags put in in this system between the roof and the coal. In the sample stall, there were two stallmen or contractors who employed two holers and two fillers and put the coals into the tubs at 1s 4½d per ton for coal. Holers hole the coal three feet under, and put in sprags every six feet as they go on. They are paid 2s 3d a fathom, and can do two fathoms in a day each. The fillers or loaders are paid from 2s 9d to 3s 9d a day. The timber is set up and drawn by the stallmen. He draws the props with a "bar and chain." The roof is a very bad one and when the props are withdrawn it falls. The packs are built partly of this rubbish and partly of the brushing. The brushing and building of packs are done by the stallmen and they are paid 2s 10d per yard in of the road, which is 11 feet wide, and brushed three feet. Powder is used in this brushing, and it is generally done during the night, but occasionally it is done during the day. After one side of the face is holed, the holers

remove to the other side of the wall, and shots are put in and the coal blown down. The powder is kept in cartridges, and the drills are all made to a gauge, so as to make the cartridges fit. The shots are fired by a competent person, and before a hole is commenced he has to be consulted. This competent person is appointed by the master, and looks after eight stalls. The roads are timbered when required. The horse road was timbered with props and crowns placed above every three feet. The props were 6½ inches at the thin end, and 7 inches at the thick end (the thin end was uppermost), and the crowns 8 inch square and 7 feet long. The props were 7 feet high, and were placed 4 inches nearer at the top than at the bottom. In the engine planes the crowns were 9 feet long. The cross roads were not at right angles to the roads but were on a slope. At the corners of the buildings shocks were placed. These were made of old timber, and were 9 feet long, 2 feet wide at one end, and 5 to 6 feet at the other. The cost for timber varied from 3d to 4d per ton, and the price was 32s 9d per 100 lineal feet for props not less than 6½ inches at the thin end. The roads were dry and dusty and were watered at irregular intervals.

SANDWELL PARK COLLIERY, near Birmingham, was also visited in this district. This Colliery works the thick coal in the way described in Mr Calderwood's paper read at the March meeting of the Institute. This being the case it was not thought necessary to give a detailed account of the working.

MONMOUTHSHIRE DISTRICT OF INSPECTION.

The special rules as to propping are :—

5.—The Overmen and their deputies shall see that all roads are kept in a safe state by the removal or otherwise of overhanging stones, or coal, or loose sides, and shall take care that a sufficient supply of suitable timber shall, after having been selected by the

workmen from the stock at the mine, be delivered at the mouths of their working places; that the timbers are set in the best manner in all places where they are required, with sprags or other props, and that each working place is examined as often as necessary.

11.—Before each shift of men, and before men are permitted to enter the Mine, the Fireman or Deputy-Overman shall examine each working place and the roadways leading thereto, to see that there is no danger from roof or sides.

31.—Every man is responsible for the safety of his working place. Every workman shall take care that he is supplied with timber from the stock at the Mine, and shall pay particular attention at all times to the state of the roof, and see that the timbers and sprags are set in the best possible manner. All stowing shall be carried up sufficiently close to the face, according to the directions of the Overman or Fireman.

Saturday, 9th April, 1881.—CELYNEN COLLIERY, Abercarne.—Owners: Newport Abercarne Steam Coal Coy. Manager: Mr J. F. Green.

This Colliery is the deepest winning in the Abercarne Valley, and has been in operation three and a-half years. There are two pits within 80 yards of each other, an upcast and a downcast. They are both 177 fathoms deep to the black vein, the upcast being circular and 18 feet diameter, and the downcast oval, 22 feet long by 18 broad. Coals are drawn by the downcast only. The winding engines have cylinders 38 inches diameter and 6 feet stroke, with Cornish valves. The drums are for flat wire ropes, and are 16 feet in diameter. Two tubs, each holding 28 cwts. of coal, are raised at a time. They are on the same level—the one placed before the other. The average daily output is 1300 tons. The upcast shaft is used for ventilating purposes only, and the ventilation is caused by a 45-feet Waddle Fan, 2 feet 4 inches wide at the tips, 4 feet 5 inches at the nave, the ear being 13 feet diameter. It is driven at 52 revolutions per minute, and discharges 220,000 cubic feet of air at a water gauge of $3\frac{5}{10}$ inches. There are two returns to the upcast, the one having

an area of 90 square feet, and the other of 100 square yards. The velocity of air in the one is 1000 feet per minute, in the other 1300 feet per minute. The Mine gives off gas, and is lighted with Mueseler Safety lamps alone. The seam is very flat.

A plan of part of the workings is shewn on Plate XI. The system of working is what is called the double stall method, and its main features are as follow:—Three levels 9 feet wide are driven from the shaft. There is a distance of 44 yards between the centre and upper level and 33 yards between it and the lower. Pairs of headings are driven out of these levels every 120 yards. These headings are 9 feet wide with a stoop of 27 yards between them. They are driven to the rise for 360 yards and stopped there, and then the double stalls are commenced at the top. A double stall consists of two places 6 feet wide and 10 yards between the centres. They are driven in off the heading for six yards and then joined, forming a stall 12 yards wide with a road along each ribside. Three stalls, each 12 yards apart, are driven off each heading at a time, and they are carried forward for 55 yards. On reaching that distance, the 12 yards pillar between each pair is brought back to within 8 yards of the heading, the stump being left to support the roof. Lastly, the stumps and the pillars between the headings are taken out. Meanwhile, other three stalls are started from each heading, and are ready to be drawn back when the others are finished. This is repeated until the coal is taken out down to within 30 yards of the level. The headings are then "bashed" or stowed up so that the waste has no connection with the other workings.* The stalls are started off the next pair of headings in precisely the same way, so that when the headings are "bashed" up there is a rib of coal 5 yards in width separating the wastes of the one pair of headings from another. This is lost. Pairs of levels parallel to the shaft levels are driven at intervals of 400 yards, so as to leave a barrier of coal 40 yards thick between the headings and the next level, and the same system of headings and stalls driven off them. After the levels have reached the bound-

* It is now proposed to drive roads in a thin seam of coal 10 fathoms above, and sink blind pits on these goaves, and so drain off the gas.

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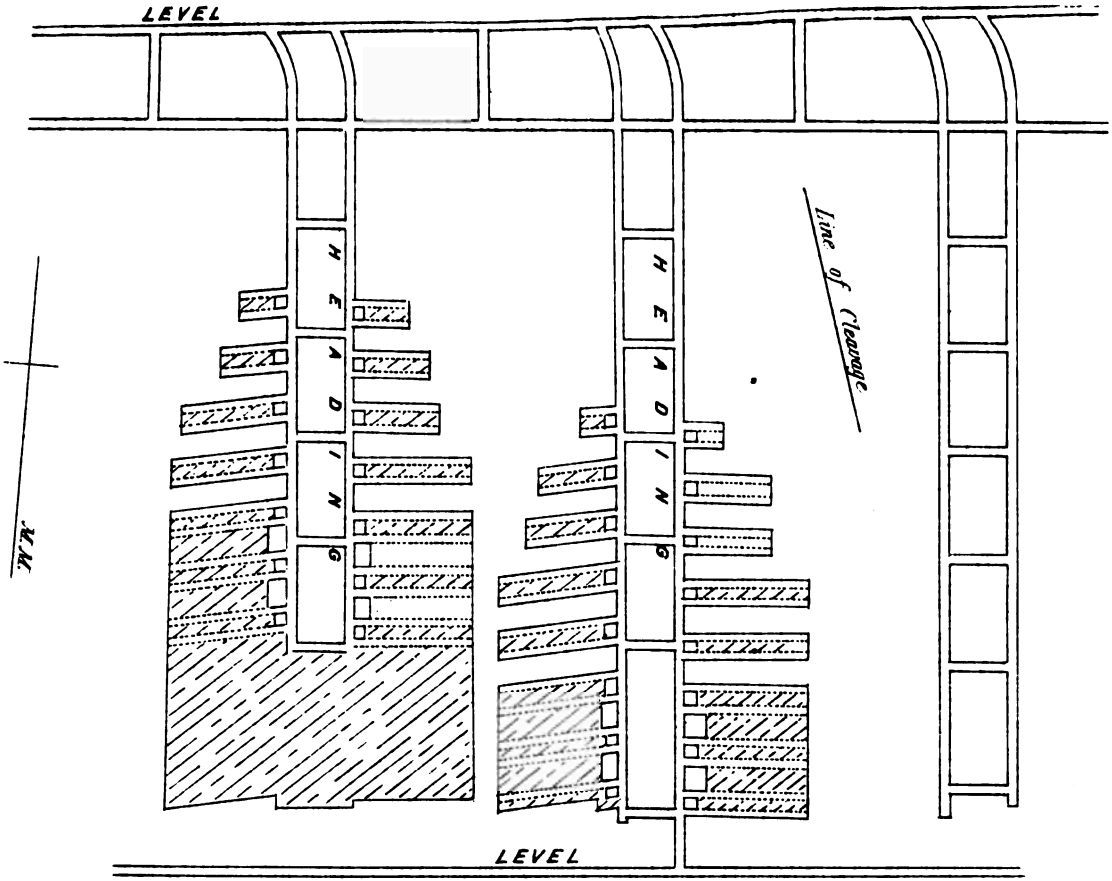


Scale

ary, and all the headings have been worked out, the stoops between them are worked back.

The following was the section in the sample place (see fig. 24) :—The coal was 9ft. 4in. thick, but 3ft. 4in. of this was

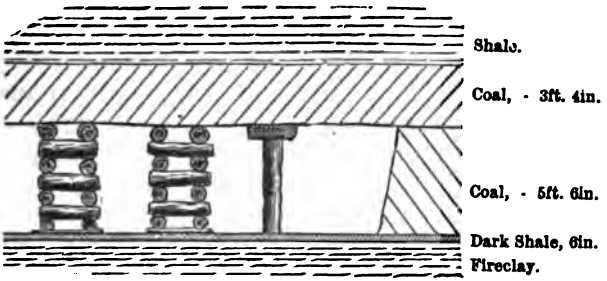


FIG. 24.—CELYNEN—BLACK VEIN—SHEWING COGS AND PROPS AT FACE OF DOUBLE STALL WORKING.

left on for a roof where the ordinary roof is bad. Above this was 5ft. 6in. of mine ground or shale with balls of ironstone, 11ft. 4in. of strong cliff with balls of ironstone, then 4ft. of mine ground with balls. On the floor were 6in. dark shale,

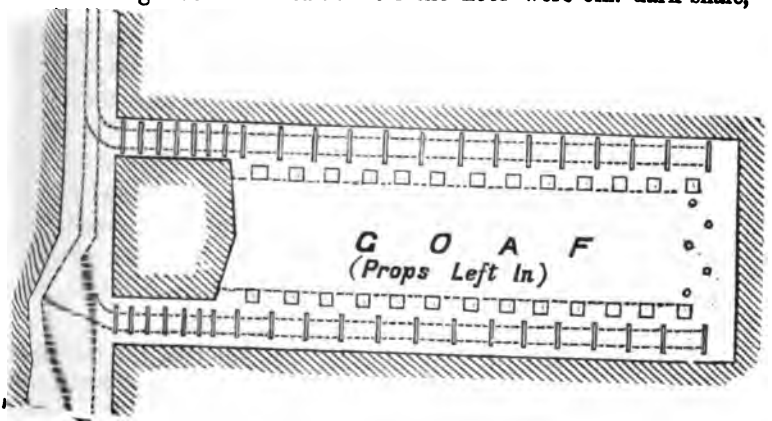


FIG. 25.—CELYNEN COLLIERY—PLAN SHEWING A DOUBLE STALL FROM THE HEADING TO THE FACE, WITH THE COGS AND PROPS.
(Scale—1 inch = 33 feet.)

and then 3ft. of fireclay. The place was 45 yards in. (See fig. 25.) In the one road there were props and gears notched in the Welsh style every 3 feet, through the opening from the

headings, and then there were four props with lids on the side next the waste; then from this to the face was timbered with props and gears every 6 feet. On the waste side of the road, there were "cogs" placed 6 feet apart, and between them old props were stretched so as to keep the small coal and rubbish thrown into the waste from falling over into the roads. These cogs were built of old props and were from 2 to 3 feet square. They are filled up with small coal in the centre. In one of the roads leading up to the sample place there were 15 cogs, and there would be as many in the other. Along the face, and 6 feet back from it, was a line of props six feet apart. These props were 10in. diameter, and had an old prop for a lid. They were put up with the thick end at the top. No particular reason was given why this should be done, and we were informed that it was just the custom. These rows were three feet apart. When the roof or coal falls close to the face small stumps or pillars of coal are left to support the roof. The collier is not paid anything for doing this. The small coal is thrown into the waste, and the roof gradually settles down upon it. The props in the face are not drawn out. In coming back, however, the props, gears and chocks are taken out, and a considerable portion of the head coal is got. The props and gears and chocks in stalls are all put up by the miner, who draws all that are drawn at 1d a prop. They also pack the stall roads when the place is finished. There are four men in a stall in each shift, and they put out three tons each. They are paid about 1s 6d for large and 5¾d per ton for small, including propping, cogging, and stowing. When they are driving through the narrow places, they are paid 1s 11d a yard, but when the place is opened out they get no yardage. The stalls are shorn on both sides, and the coal comes off in slabs without any holing.

The top coal is of better quality than the rest, and in some places where the roof is good it is worked out and two feet of the bottom coal left on, except in the roads. When this is done, 4 inches of inferior roof coal is left on, and there are lids put on the crowns, not running from crown to crown, but with the crown in the centre of the lid and the ends overhanging. Otherwise, the working is the same as when the top coal is left on.

In the main roads the timber is put up where required, there being an understanding, however, that the props and gears are not to be more than four feet apart. The timber is notched in the Welsh fashion. The legs and crowns are 8in. to 9in. thick. The height of the roads to the inside of the crown is 7 feet, and the width at top is 6 feet, and at the bottom 10½ feet. This form of timbering is adopted on account of the side pressure, which at this depth is very great. Although the depth at the shaft is only 177 fathoms, the workings go immediately under the mountains where they have not less than 350 fathoms of cover. The timbering of the roads is done by a special class of men who work during the day. They work in pairs and are paid 1s 8d a pair of 9ft. timber, and in addition are paid 1s 6d per ton for the coal taken down from the roof. The cost for timber is 9d a ton on large coal. This would be 7d on the gross output. Wood costs 23s 6d a ton at the works.

MONMOUTHSHIRE DISTRICT OF INSPECTION.

Saturday, 9th April, 1881.—RISCA COLLIERY, Cross Keys Station, near Newport. Owners: Messrs London and South Wales Coal Company (Limited). Manager: Mr G. W. Wilkinson.

This colliery began to work coal in June, 1878, but it is now only getting into full working order after the explosion of 1880. There are two pits, an upcast and a downcast, both 17½ feet diameter, and 142 fathoms deep. The downcast is fitted as a winding shaft with single-decked cages, carrying two trams, each of which holds 18 cwt. of coal. The output is 1200 tons per day of 16 hours. There are wire rope conductors in the shaft, six ropes being used, the two on the outside of the cage passing through guides, and the two in the middle, between the cages, to prevent them touching each other, so that at the meetings there is only the thickness of the rope between the cages. There is a pumping engine, pumping from 600 to 700 gallons of

water per minute, which comes from the old workings to the rise. The other pit is used solely as an upcast, and a 40 feet Guibal fan is put on it. The water-gauge is 3½ inches and there are 180,000 cubic feet of air per minute going through the workings. In the main airway the current has a velocity of 20 feet per second.

The workings are in the black vein. The seam is generally flat, but in some parts it dips as much as 1 in 14. The pit is sunk in the valley, but the workings run under the mountains, and have a cover of about 250 fathoms. They work coal two shifts of 8 hours, beginning at six a.m. and stopping at ten p.m., and use the other eight hours for a repairing shift. The mode of working is by long-wall, with nine yards between the roads (see plan, Plate XII). In the sample place the excavation

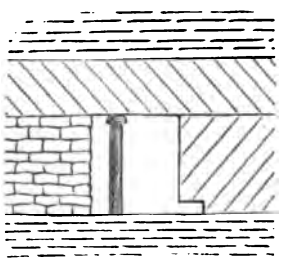


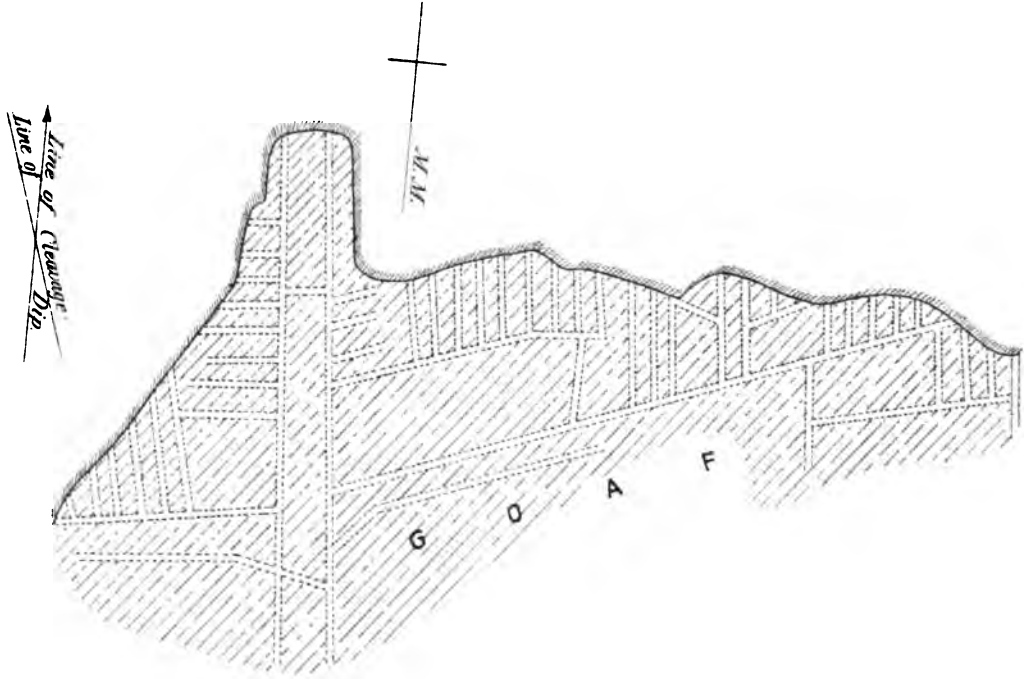
FIG. 26.—RISCA—BLACK VEIN.

was six feet, three inches. (See sketch, fig. 26). There were three feet of coal left on for a roof, and above this were six feet of shale. Above this was rock. The shale varied very much in thickness through the pit. Sometimes there was none, and sometimes it was 20 yards in thickness. The pavement was five to six feet of soft fire-clay which rose in the roads, and below this was harder fire-clay which, however, also rose in the roads. The "Cundies" are filled with small coal and "redd" got from the repairing of roads, and the roadsides are faced with stone brought down from the surface at a cost of 1s a ton. The props are put in by the men where they are required, and there is no special distance at which they should be set. These props are

PLAN OF PART OF RISCA COLLIERY.

Reduced from Working Plan.

PLATE XII



Scale

not taken out, as they would leave holes in the roof for gas to collect in. At the road heads, 10-inch props are put in about a yard apart, but those between the roads are five inches to six inches in diameter. There are two men and a boy in each stall, and they put out nine to ten tons per shift of eight hours. They work from six in the morning till two, and are relieved at that time, and the next shift works till ten p.m. They take charge of the place and the roadway for 40 yards back, and are paid at the rate of 1s 6d a ton for large hand-filled coal. The cleavage planes of the coal lie in a sloping direction, and are very distinctly marked. In consequence of this the coal comes off in very large pieces, and all the collier has to do in working it is to lift it off in irregular lumps with his pick. There is no holing unless in very exceptional circumstances.

Close to the face, the coal which was left on made a good roof, and little timber was required, but at 150 yards from the face, the full subsidence has taken place, and this coal requires to be taken down in the roads to give height. When this is done timber is required, and as there is an enormous side pressure it is put up in the Welsh method, notching the crown and props. Larch and French timber, 10 inches diameter, are used, and in the horse road we were in, the gears were put in every three feet. At the crossings of roads there are what are called square timbers or framings, which consist of an ordinary pair of timbers set across both sides of the openings, and crowns stretched between their crowns and notched into them. These timbers are put in by a special class of men called timbermen, who work during the night from ten to six. They are paid 4s 6d and 5s a shift. There are a few chocks put in by the colliers at the corners of buildings, and for these they are paid 1s a chock, but very few are used. When the roads are abandoned, the timber is drawn out and they are stowed up tight, the stowing being got from the falls which are continually taking place in the roads.

Brick arching will not stand the side pressure, and at a point in the main road stone walls were built up at the side and strong oak beams laid across between them. The cost for timber is 5d a ton, and wood costs 21s a ton at the pit.

The roads are dry and dusty, and are watered so as to keep the wet and dry bulb thermometer the same in the return. There are firemen who look after the ventilation, but they have nothing to do with the propping, which is done by the miners. They visit the place twice in the shift of eight hours.

Mr Wilkinson, the manager, who has had considerable experience in the North of England, North Wales, and North Staffordshire, gave it as his decided opinion that the deputy system as practised in Durham would never do in Wales. The deputy would require to be constantly standing beside the man to be able to prop his roof securely, as it was so very deceptive. In fact, he was of opinon that even in the North of England the propping could be much better and more cheaply done by the men than by the deputy.

SOUTH WALES DISTRICT OF INSPECTION.

61.—The Overman shall immediately cause any fall which shall obstruct any airway or roadway to be removed, and every defect therein to be made good.

62.—He shall direct all loose overhanging stones or coal in the roof and sides of all working places and travelling roads to be removed or propped, and made safe as required by No. 16 General Rule.

63.—He shall direct that timbers are set in the best manner in all places where they are required, and shall take care these directions are obeyed.

65.—He shall require the Colliers and other persons employed in the Mine properly to stow away all rubbish in their stalls and working places, and to remove all loose overhanging stones or coal in the roof and sides, and to put up all necessary props, walls, and gobbing to make their working places safe. But he shall see that any deficiency of rubbish requisite for making any Collier's working place safe shall be conveyed thereto and properly stowed away.

66.—He shall direct that all timber set aside and prepared by the Colliers shall be conveyed to the Colliers' working places, and shall take care that these directions are obeyed.

78.—The Firemen shall maintain over the timbering, and all things connected therewith, a careful supervision, so as to ensure the safety of all persons in the Mine.

79.—He shall cause all loose overhanging stones or coal in the roofs and sides of travelling roads to be removed or propped, and the roads to be made safe.

80.—He shall direct and see that timbers are set in the best manner in all places where they are required.

81.—He shall require sprags or short props to be used by the Colliers wherever needed in the working places.

82.—He shall require the Colliers and other persons employed in the Mine properly to stow away all rubbish in their stalls and working places, and to remove all loose overhanging stones or coal in the roofs or sides, and to put up all necessary props, walls, and gobbing to make their working places safe. But he shall see that any deficiency of rubbish for making any Collier's working place safe, shall be conveyed thereto and properly stowed away.

83.—He shall examine every working place at least once in every turn, or oftener, if necessary, to ensure the safety of all persons working therein.

84.—He shall instantly stop every working place that may, for want of timbering, be in an unfit state to work in.

Colliers.

208.—The Collier shall strictly observe the requirements of the Overman and Fireman, as stated in Rules 62, 65, and 82, so as to ensure the safety of his working place, and shall at the commencement of each turn before he begins to work therein, and at the proper intervals during his turn while working therein, carefully examine the face, roof, and sides of his working place, to satisfy himself that the same is safe.

209.—If upon any such an examination by a Collier of his working place, any danger, want of repair, or unsafeness is found, he shall cease all operations therein until such danger is removed or such want of repair or unsafeness is made good; and he shall

immediately proceed to remove such danger, and to make such repair good, and to render his working place safe in every instance where it is his ordinary duty so to do; but if the same is not a part of his ordinary duty to do, he shall immediately report such danger, want of repair, or unsafety, to the Under-Manager, Overman, or Fireman.

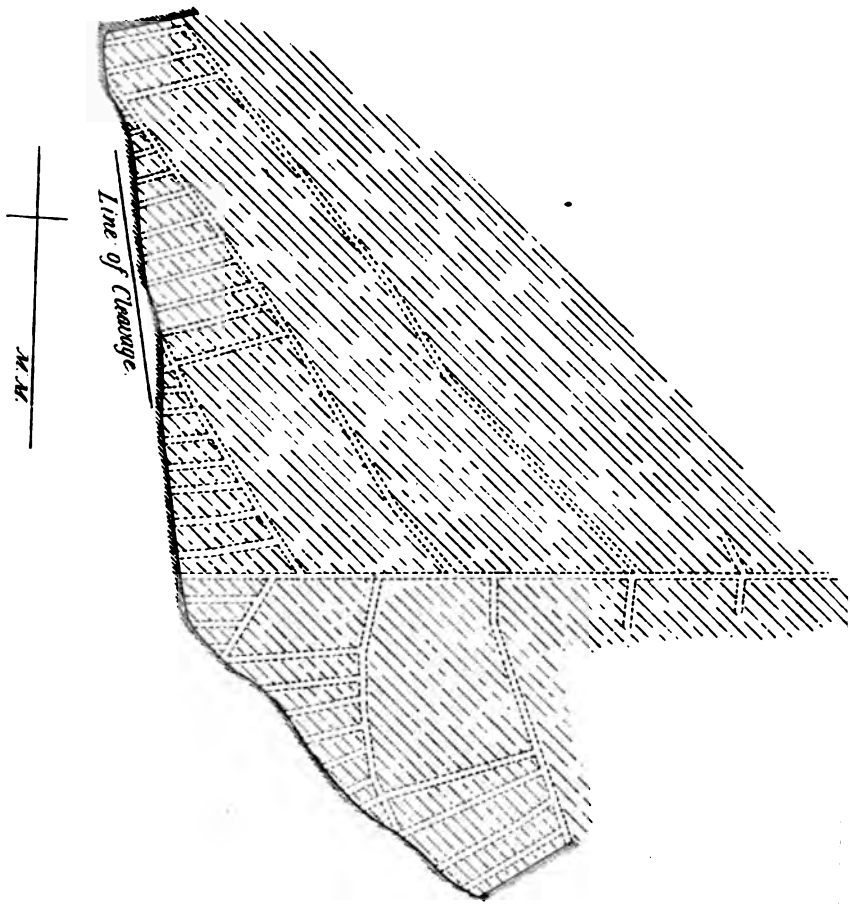
Monday, 11th April, 1881.—OCEAN COLLIERY, Treorky, Glamorgan. Owners: Messrs David Davies & Co. Agent: Mr William Jenkins.

These are extensive collieries, comprising five coal-drawing shafts, with an equal number of upcast ventilating shafts, all of which work the Ocean (Merthyr) Smokeless Steam Coal—the total output being about 4,500 tons per day. All of these pits are at present ventilated by furnaces, a furnace being placed at the bottom of each upcast shaft. A change in this respect is now in progress. They are putting up a 45-feet Waddle Ventilating Fan at one of their shallowest shafts to replace the furnace thereat. We visited the Cwmpark Pits, which are 100 fathoms deep. There are two pits—an upcast and a downcast. The upcast is used for ventilating purposes only and has a furnace at the bottom of it. The downcast is used for winding coals. In it are two cages—one up and the other down—on each of which is placed a single hutch called a tram, holding two tons of coal. The trams are of iron with sheet iron curbed sides and two crossbars at each end. The gauge is 3 feet. The body of the tram is placed within the wheels. The wheels run loose on the axles and the axles loose in the guides or carriages under the tram. The coal is large and is filled or walled to the extent of about 3 feet above the sides of the trams. The rails underground are very heavy. In the engine plane they are flat-bottomed, weighing 40 lbs. to the yard, and in the roads to the faces 22 lbs.

The coal lies very flat. The workings are by the long-wall method with the roads level and 12 yards apart, and there are headings cutting these off every 50 yards, resembling very much our Scotch long-wall working. A plan of part of the workings is

PLAN OF PART OF OCEAN COLLIERY.

Reduced from Working Plan.



given on Plate XIII. In the sample place the following was the section. See fig. 27. On the top of the coal were "cliff" (hard

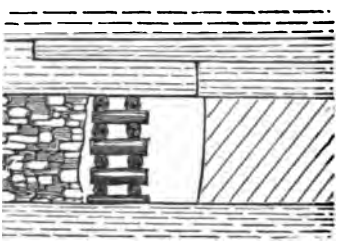


FIG. 27.—OCEAN—STEAM COAL.—PLAN SHOWING FACE OF SAMPLE PLACE.

black shale) 2 feet, "cliff" 1 foot, "cliff" with nodules of ironstone 4 yards, then beds of rock from 6 inches to 4 feet thick. The pavement is 9 ft. of fireclay, and coarse fireclay with nodules of ironstone below. The 2 feet of "cliff" next the coal is taken down in the roads at the faces, and built into the waste. This is done by the collier, and the face of the brushing is kept within a foot of the face of the coal. The second bed is taken down as a second ripping in the slope road and when the stalls get too low, and is also built into the waste, so that with the small coal it is nearly filled. The sample place was the stall next the heading and between it and the face of the heading there were eight 6-inch props with lids made out of split props. There was a row parallel to the face and about 3 feet back from it with the props about 6 feet apart, and there was a 3-feet chock at the corner of the building next the face, both at the stall and the heading. There is no fixed distance for the timbering, the props being put in by the collier wherever they are considered necessary. The roof is a good one. There were a few slips in it, and, as far as we saw, this was the only bad thing they had to contend with in it. The chock at the face of the stall was not a regular thing, but was put up merely because it was near the heading.

In the road leading to the stall there was no timbering, but along the heading there were chocks on both sides of the road. On one side of the heading there were three chocks in the space between two stall roads, one at each corner of the building and one

between the roads; on the other side there was a row breaking band with these. The chocks were made of old round timber and were about 3 feet long and filled with rubbish in the inside.

All the timber, props, and chocks in the heading were put in by the collier, who was paid extra for doing it. He gets 1s 7d a ton of screened coal for hewing, filling, and setting props. The coal is filled all large pieces into the tubs at the face. There were two men in each stall and they put out about 6 tons a day. For setting the chocks in the heading he was paid at the rate of 1s 11d a chock. For drawing timber he gets 1d a prop. For brushing he was paid 1d per yard per inch in height, width not less than 5 feet in top of ripping—the road being 10 feet wide at the bottom. For the first brushing—2 feet thick—he was paid 2s a yard for the necessary width. The main roads are timbered with props and gears which are not set up at any specified distance apart. In the heading they were set about four feet apart. The timber was 11 inches diameter and

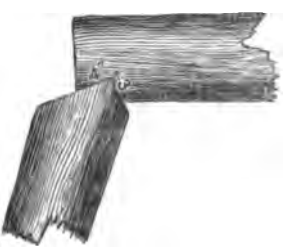
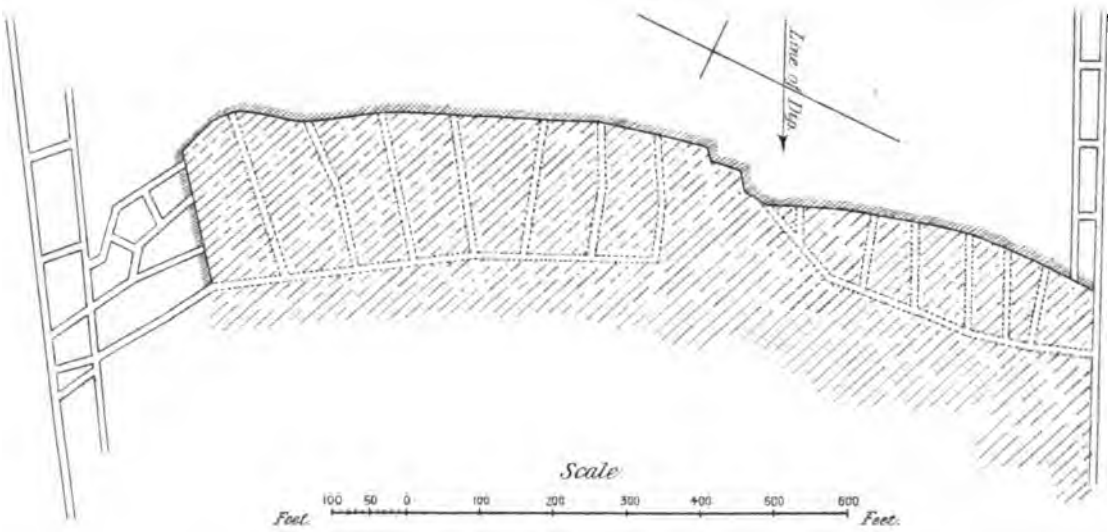


FIG. 28.—JOINT OF WELSH TIMBERING.

was notched in the Welsh style. See fig. 28. This timbering is done along with the second ripping and is put up by a set of repairers who work during the night. These men are paid 2s for each set of 9 feet timber and are paid extra for opening out headings. There are firemen in the pits, one to each district of about 40 or 50 places. They are responsible for their respective districts, but have no actual labour except putting up doors and sheets or an air tube. Timber costs about 24s per ton or about 11d a cubic foot at the works. There was a road being driven

PLAN OF PART OF PEMBERTON COLLIERY.

Reduced from Working Plan.



through stowing which had been standing for a year and a-half and was 150 yards back from the face. It had subsided from 5½ feet in the working to 3 feet 4 inches.

LANCASHIRE DISTRICT OF INSPECTION.

PEMBERTON COLLIERY, near Wigan. Owner: Colonel Blundell. Manager: Mr W. J. Greener.

The special rules as to propping are the same as those in use in the Manchester district of inspection. See page 103.

This colliery has been in operation for about ten years. There are four pits a short distance apart: the King Pit upcast, the Queen Pit downcast, a shallow pit, also a downcast, and the pumping pit. Only the King and Queen Pits wind coal. The winding engines are between the pits, and the two engines are in one house. They have both 36 inch cylinders with Cornish valves. On the Queen Pit there is a scroll drum, beginning at 19 feet 8 inches diameter, and going up to 30 feet 10 inches. It weighs about 48 tons. Six tubs each holding 8 cwts. are wound at a time, two tubs on a deck and 3 decks in each cage. The King Pit drum on the Wigan four-feet rope side is 15 feet 2 inches, the Cannel side is a scroll from 15 feet 2 inches to 19 feet 4 inches.

The stones are picked out of the coal in the following manner:—At the foot of each screen is a band of flat hemp ropes fastened together by iron bands. This is 14 feet long and goes round pulleys at either end. There is a shaft constantly revolving by the side of these bands and a clutch by which they can be thrown in and out of gear. When a hutch is about to be emptied over the screen the wheel is put into gear and the band kept going at the rate of about 35 feet per minute. There are doors on the end of the screen which are worked by a lever, letting the coals fall thinly

on the band. When all the coals are on it is then stopped, and two women, who are one at each side, pick out the stones. When the coal is thoroughly picked the band is set in motion again and the coals put into the waggon. In this way 100 to 120 tons a day are passed over each screen, but this amount could be vastly increased if required.

The small coal is led into a pit below the screens. From thence it is carried by means of a screw working in a trough and is lifted by an endless pitch chain with iron buckets like a dredger, where it is screened and the duff taken out. The ventilation is caused by a Guibal fan, 46 feet diameter and 14 feet 10 inches wide. It is driven at 36 revolutions per minute and gives 275,000 cubic feet of air at a water gauge of 2½ inches. The water is lifted by a direct acting pumping engine, which raises its load from a depth of 95 fathoms by a 20 inch brass bucket for the bottom 35 fathoms, and a 20 inch ram for the remainder of the distance. It is driven at the rate of 10 strokes a minute.

The Queen Pit is sunk to the Arley seam, which it works at a depth of 313 fathoms. It also works the Orrell five feet at a depth of 283 fathoms. All the coals are lifted from the bottom in the Arley seam. Those from the Orrell five feet seam are let down by means of a blind pit with two cages, the rope going over one of Fowler's clip pulleys. There is one hutch raised at a time, the full one pulling the empty one up. The man at the Orrell five feet seam loosens the brake on the pulley and lets the cage run down. Our observations were confined to the Orrell five feet seam, which is a household coal. It is of a tender nature and yields 61·3 per cent. of round coal, passed over an inch screen. It is worked by the long-wall method. It used to be worked by the pillar and stall method, with pillars 20 or 30 yards square, but this method is being given up in favour of the long-wall method, and only the pillars are being removed. The seam dips at an inclination of 1 in 12 and the coals are brought from the level next the face to the top of the blind pit by means of a "spunney" or self-acting incline. The roads are driven to the full rise and are 30 yards apart from centre to centre. They are cut off every 100 yards by levels running at right angles to them.

These levels are 8 feet wide and have packs 4 yards wide built on each side. The roads to the face or brows are 7 feet wide, and there are 3 yards buildings on each side.

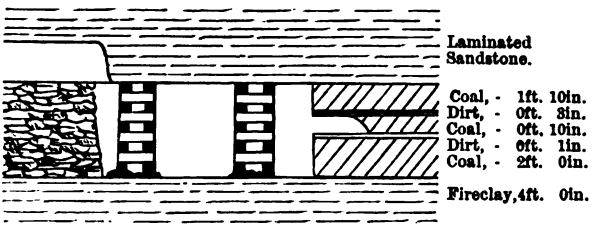


FIG. 29.—PEMBERTON.—ORRELL FIVE-FEET SEAM.

In the sample place the working was 5 feet thick. (See section, fig. 29.) The roof consisted of "lea stone" or laminated sandstone (grey fakes), with ironstone balls, and 2 feet of this was taken down in the roads. The floor was "sagger" or fire-clay. There is no regular holing, but when the coal is holed it is done in the 10 inches of coal in the centre. The bottoms are then lifted up and the top coal supported on sprags, which are put in by the collier. When these are knocked out the coal falls. Props and sprags are put in by the Collier when they are required. These props are three to four inches diameter. There were four men in the place, two on each side of the road, and they drew their own stuff out to the "spunney," a distance of 100 yards from the face. In some instances two men employ a young man as a putter and he assists to fill and draw the coal; but this was not the case in the sample place. The collier got for holing and drawing 1s 3d a ton. There were pack walls 3 yards wide on each side of the road, and a double row of chocks 6 feet apart carried all the way along the face. (See fig. 30. The two rows were 5 feet apart, and the rails laid and the hutches taken in between them. As a third row of chocks is put in, the last one is drawn and shifted forward. The roof breaks off behind the chocks. These are put in by the fireman, and are built on 4 or 5 inches of small coal. They consist of billets of wood 2 feet long

and 6 inches square, and are very quickly put up. We watched a fireman do so and found that it took him five minutes to put it

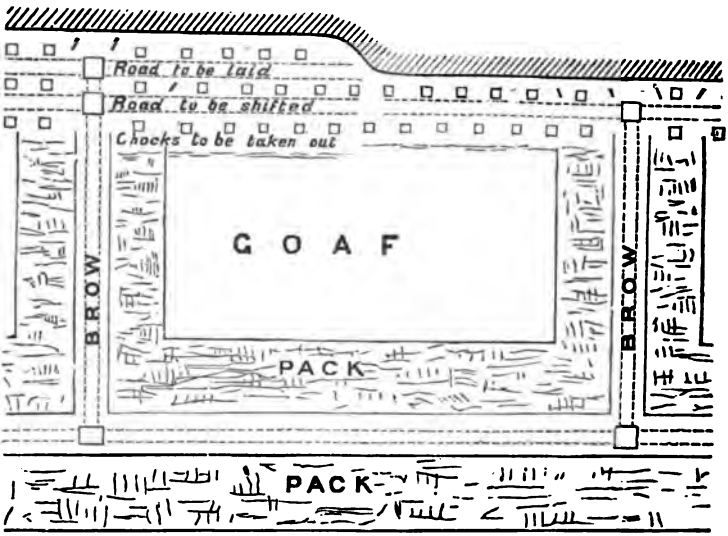


FIG. 30.

up and wedge it tight. The fireman is paid by day's wages and attends from 20 to 30 men. The ripping is let to a contractor who takes out 12 feet from either the roof or the pavement of the roads, draws the chocks and other timber and puts in the packs, which are kept within 3 or 4 yards of the face. He is paid 10s a yard for the brushing and putting in of packs. He takes out the props and chocks and gets 2s 6d a score for large props, but nothing for small ones, and 9d a chock. Sometimes if the roof is tender and requires a chock he puts it up and gets 3d for doing so, but the fireman is supposed to put them all in. The props which were put in by the collier were removed when the chocks were put in.

There is little or no timbering in the main roads, but where it is required props and gears are put up without notching. There is a special class of men for putting in this wood. There is a man in charge of the night shift, and he sends men to

repair the roads where required. The roads are dusty and are sprinkled with water, but there is not much put on, as it would cause the pavement to rise. There is no blasting in this seam, the only seam in which there is any being the Pemberton 5 feet seam.

In the pillar and stall workings the pillars are 20 yards by 30, the levels being 3 yards and the drifts 4 yards. We did not visit these workings, but were informed by the Underground Manager that 5 yards lifts called "ratches" were taken along the whole 20 yards of the pillar, and after three had been taken out lifts were taken out up hill. While the 5 yards lift is being taken up the hill a line of props and gears is kept over the road. There are three rows of props and lids on the waste side of the road, the trees being 3 feet apart and 3 feet between the rows. The trees are about 6 inches diameter at the thick end, and 4½ feet long. The lids are 18 inches × 5 inches × 2½ inches, and are made out of old gears or props. In a lift of 20 yards there were 100 props, three rows of 20 and the double row over the road of 40. The trees are all put up by the miners but are drawn by the firemen. When a lift is finished the fireman takes out the props at once and does not wait till the men are out of the pit, but arrangements are being made for drawing all the props during the night. Of course, if a lift will not stand till then it will be drawn at once. If the pillar is fallen close a strip 3 yards wide called a "ribbing" is carried to the top and the lifts taken out in the usual way. The cost of timber is 1d per ton in the long-wall, and in the pillar-and-stall workings about ¼d per ton. In working out the pillars the cost will be about the same as long-wall. Prop wood costs 25s per 100 lineal feet, or 37s a ton at the pit, and the billets of wood for chocks cost 7d each.

MANCHESTER DISTRICT OF INSPECTION.

The special rules as to propping are:—

Securing of Roofs and Sides.

19.—Under this Rule the Underlooker, Fireman, or other com-

petent person appointed for the purpose, shall see that sufficient props, chocks, sprags, and other supports are provided, and that the roofs and sides of the travelling roads are secured where necessary by the persons employed for the purpose. He shall also cause Special Rule 40 to be observed.

Spragging and Propping.

40.—The miner shall secure the roof and sides of his own working place, and if he should not have sufficient sprags and props, or other material for the purpose, he shall cease working, and he shall report the same to the Manager, Underlooker, or other person in charge of his part of the workings. He shall set sprags or holing props as soon as there is room, and he shall afterwards keep them set during holing. After taking out the sprags or holing props, if the coal or other mineral will not fall with wedging, or from the effects of the shot, he shall not hole further until he has re-set the sprags or holing props. On returning after a shot has been fired, he shall carefully examine the roof and sides of his working place to see whether they have become loosened. . . . When taking out props likely to occasion a fall of roof, and to give off fire-damp, the miner or prop-taker shall use no light other than safety lamps. In pillar and other working, before commencing to remove pillars, the miner shall secure the roof and face, and when commencing to drive a new place he shall guard against a fall from a level break or crack.

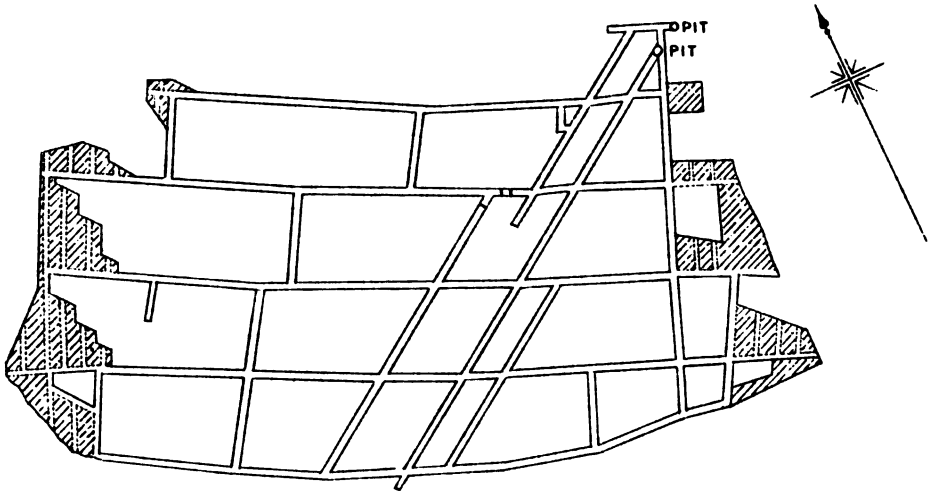
*Clifton Hall Colliery, near Manchester.—Owners: Messrs A. Knowles & Sons (Limited). Agent: Mr S. Horrocks.

This colliery has been in operation for 27 years, and at present works the Doe, Five Quarters, and Trencherbone seams. There are two pits, the one a downcast and the other an upcast, both of which are sunk to the Trencherbone seam. The downcast alone

* As the plan of this Colliery was not forward at the time of going to press we have shewn on Plate XV. a plan of Unity Brook Colliery, taken from a report by Mr Dickinson, the Inspector of Mines for the Manchester District, on a serious explosion which occurred there in 1878. The method of taking lifts up the hill is the same as at Clifton Hall, in the Trencherbone seam.

PLAN OF UNITY BROOK COLLIERY,

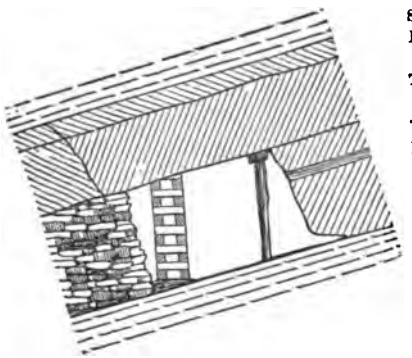
Cannel Mine.



is used for winding. A level cross-cut is driven from the Trencherbone seam to the Five Quarters and the Doe seams, so that all the coal is drawn from that level (270 fms.). There are spiral drums on the engines, and the cages are three decked. In order to get over the difficulty of shifting the tubs off at top and bottom at the same time there is a balanced scaffold at the bottom. The shifter at the bottom changes the lower tier of tubs first; he then lowers the scaffold by means of a brake, and changes the upper tiers. In this way 600 tons a day are raised. The ventilation is caused by a furnace and the steam from an engine and some boilers which are used for hauling coal from the workings. The quantity of air is 100,000 cubic feet per minute.

The strata dip at an inclination of 1 in 3½. The method of working is by driving levels to the boundary and then working back towards the shaft. We visited a pair of levels driven in the Doe coal which is 50 fathoms above the Trencherbone. From the end of the cross-cut mine a pair of levels 30 yards apart are driven to the boundary. Cut throughs are driven about every 40 yards. There is another pair of levels 200 yards to the rise, and the coal is left solid between them. When the boundary is reached, a pair of places 30 yards apart are driven from a point 200 yards back from the boundary, until they hole on the upper level. Levels and throughers, 7 feet wide, are then driven, dividing the 200 yards into 30 yards pillars; these pillars are then worked off in lifts 12 yards wide, and the coals drawn down the levels. While these pillars are being taken off, another range is being driven 200 yards back, so that at no time is there more than one section of pillars being worked. In the sample close place driving towards the boundary in the Doe seam, the following was the section. (See Fig. 31):—The seam, including the 7 inches of dirt, was 9 feet thick, but 3 feet 6 inches of this was left as a roof. Above this were 12 inches of "cat" coal, 18 inches of soft black stone, 3 inches of ironstone, 3 feet 6 inches of hard, brittle (short) shale; and above this white metal. The pavement consists of 18 inches of warren earth or fireclay, and below this is a hard grey metal. The 7 inches of "Daugh" is holed for a yard under and then the top coal is taken down. This is carried forward until there is 9 feet of bottom coal bared, and then it is lifted

up by blasting. The men are paid at the rate of 6s per 3½ tons of coal riddled through a ¾-inch riddle. The place was 7 feet



Soft Black Stone, - 18in.
Bad Cat Coal, - - 12in.
Top Coal, - - - - 12in.
Top Coal, - - - - 17in.
Fireclay, - - - - 7in.
Bottom, - - - - 42in.
Fireclay - - - 18in.

FIG. 31.—CLIFTON HALL—SECTION OF DOE COAL.

wide, and was ventilated by brattice from the last throughter, 5 feet on the dip side being the intake, and 2 feet on the rise the return. The throughers are driven 5 to 6 feet wide. The coal left on makes a good roof, and no timber is required at the face; but this coal is taken down farther back and the fireclay lifted, and when this is done, gears require to be put in, and a considerable quantity of timber is used. These are put in where they are required by men appointed for the purpose, there being no specified distance. They were put in at distances of about a yard in the road we were in. Both props and gears are 8 inches diameter, and the legs are rounded on the top so as to receive the crown. In one or two instances we observed that when weight had come on the crown the leg had been split down the centre as with a wedge. Rafters are put in from crown to crown, and laggins are put in between the rafters. There are cleats called "shuttles" in the coal running at right angles to the dip and rise, and these very often set free blocks of coal which roll over on to the roads and are very dangerous.

In the pillar workings the whole of the seam is taken out. The sample place of pillar working in this seam was 1700 yards from

the cross-cut mine. It was a pillar on the side of the level. One lift of 12 yards had been worked off and a second was 15 yards

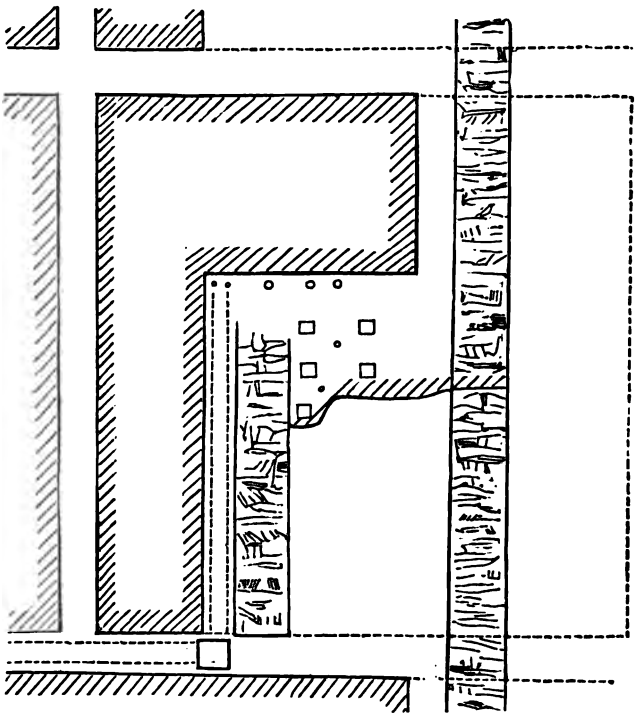


FIG. 32.—CLIFTON HALL—DOE COAL—PLAN OF LIFT.
(Scale—1 inch = 33 feet.

up. A road, 6 feet wide (see Fig. 32) was carried up the side of the coal, and on the waste side of the road a 9-feet building was made of the cat coal. There were two chocks 6 feet back from the face 5 feet apart and parallel to it; 5 feet to the rear of these was another line of chocks, and 5 feet behind these was one of a third line ready to be taken out, the other having been removed. These chocks were built of billets of wood 2 feet long and 6 inches square, and were built upon 4 inches of coal. When they did not come close to the roof, slips of wood were put in between the roof and the last block to make up the thickness. Between the chocks

and the face, and close to it, was a line of props, and there were other two between the chocks further back. Altogether, there were 5 props and 5 chocks in the face. The props were of larch and were 3 inches diameter and 5½ feet long. They were set with lids 18 inches long and 5 by 2½ inches broad. As the last row of chocks was withdrawn the head coal came down in the waste and was taken out. In this place there were three men and a lad, and these cut the coal, let them down the jig brow, built the packs, and set and draw all the timber. For the coal they get 6s 3d for 10 waggons or 3½ tons, and 4s a yard for building the packs. The coal is riddled through a ¾-inch riddle, and they get 2s 6d for 3½ tons of slack. There is 20 per cent. of slack. This place got 10 tons a day. The Fireman looks after the propping and sees that a sufficient number of props and sprags are put in.

The roof in the roads is not good, in the working it is only exposed in the waste. The cost for timber in this seam is 2½d a ton.

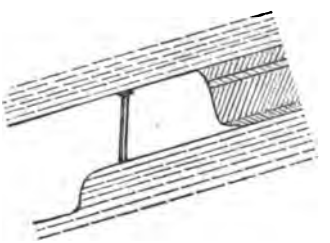


FIG. 33.—CLIFTON HALL.—FIVE-QUARTERS COAL.

The Five Quarters seam is 12 fathoms below the Doe. The working is 3ft. 4ins. in thickness (see fig. 33), but only 22ins. of coal is sent out. This is of excellent quality. The roof is hard sandstone, which continues all the way up to the Doe coal. The holing is in the daugh. The floor is "warren earth" or fireclay. In brushing, some water is put on it and then it becomes quite soft and easily lifted up.

In this seam, instead of driving a pair of 7 feet levels 30 yards apart, only a single level 13 yards wide is driven. These levels are 140 yards apart. The road is to the one

side and has 6 yards of a building to the rise side and 3 yards to the dip. On the rise side of the place is an air course 3 feet wide, which is carried along the coal. There are packs on each side and an airway down one side of the coal till it is holed. In this way a pillar 140 yards square is left and the air carried forward. When the levels reach the boundary these pillars are worked off in 20 yards lifts, the road being carried up the centre with buildings on both sides. The sample place was 30 yards up. The road was in the centre of the place, and there was sufficient rubbish with the brushing to fill up the entire space like a long-wall working, the roadsides being merely faced up with inferior coal. The air was carried along the ribside. There were no chocks, props being put 6 feet apart along the face. These props were 3 inches in diameter, 3½ feet long, and had a lid 2 feet × 5 inches × 2½ inches. They are not set vertical nor at right angles to the seam, but lean a little to prevent the weight riding over. The collier was paid 8s 8d for 3½ tons of riddled coal, and he took it down to the foot of the second jig brow for this, a distance of 200 yards. He is paid 3s a yard for the packs and puts in all the props. There are four men in a road and they put out seven tons a day. It is found that this seam works very badly if the Doe coal has been worked over it. The roof being rock, it is, of course, very good.

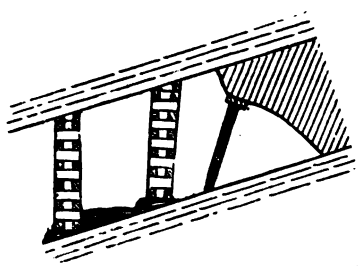


Fig 34.—Clifton Hall.—Trenchbrsone Coal.

The Trencherbone coal is 90 fathoms below the five quarters. Fig. 34 shews a section of the seam. The coal is 6 feet thick and has for a roof 4 feet of laminated sandstone. Above this is a thin

"chitter" coal 15 inches thick, called the California coal, and above this is a very hard red sandstone 24 yards thick, called the Trencherbone rock. The floor consists of 18 inches of "warren." Immediately beneath this there are 4 feet of "warren," then 4 yards of shale, a thin coal and then shale. This coal is worked in the same way as the five quarters, with levels driven in the same way. In this seam, however, the pillars are left 100 yards square, and instead of only one lift being taken up the pillar at a time, there are two and sometimes three going uphill at the same time, and one or two going down. The coals from those places going down are drawn up by means of a windlass. This is done by the collier,

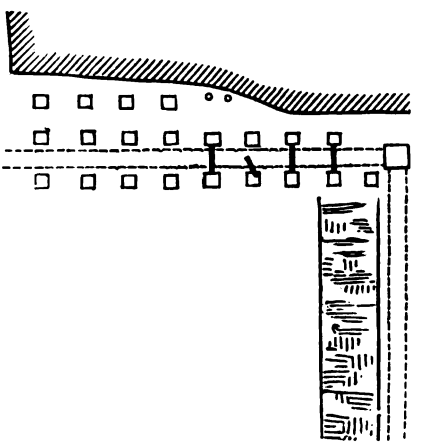


FIG. 35.—CLIFTON HALL—TRENCHERBONE COAL—PLAN OF LIFT, SHEWING CHOCKS AND PROPS.
Scale—1 inch = 33 feet.

who receives nothing extra for doing so. The lifts (fig. 35) are 20 yards wide and they are kept 20 to 28 yards the one in front of the other. The road is carried up the centre of the lift, and there is a 3 yards' building carried up each side. There are two rows of chocks 5 feet apart kept next the face, and the rails are laid in between. When the face has advanced far enough another row is put in and the last one taken out. Before the chocks are taken out props are put in all around. The chock is

taken out by clearing away the dirt from the foot and knocking out the bottom. The props are then taken out and the roof comes down. Sprags 5 feet 6 inches long, with wedged sharped lids (fig. 34) are put up against the coal to prevent it riding over. The roads are dry and dusty. There is not generally much timbering in the main roads, but in some places the roof is bad and props and gears with cross pieces and laggins are put up. The legs are of different thicknesses, the one to the dip being 5 inches diameter, and that to the rise 4 inches. The crown is 7 inches. This system of working is said to be an advantage, as it takes the weight off the roads and keeps it on the face. There is no blasting in working off the stoops.

Wednesday, 13th April, 1881.—PENDLEBURY COLLIERY.—Owners: A. Knowles & Sons (Limited). Manager: Mr Simon Horrocks.

This Colliery belongs to the same company as Clifton Hall, and is adjacent thereto. It has been in operation for 33 years, and works the Shuttle, Crumbouke, and Ram's Mines. There are two pits—an upcast and a downcast. The downcast is 200 fathoms deep to the Shuttle and Crumbouke coal. There is a direct acting pump at the bottom of this pit which pumps the water to the surface in one lift. The No 2 Pit, or Furnace Pit, is the upcast, and coals are wound in it from the Ram seam. The men ride in this shaft, which is very hot, and they have a signal to the bottom, so that if by any accident the cage is stopped in the shaft, they may open the separation doors and let the air into the shaft. The Ram seam is 100 fathoms above the Doe seam, and is 5 feet thick. It is worked in the same way as the Trencherbone at Clifton Hall. There are an engine and boilers at the bottom of the upcast, which raise the coals from a place driven 500 yards to the dip; this road is arched with brick all the way down. We visited the lowest level driven from this. At the foot of the "dook," and for a short distance along the level, there are some

double-headed rails used as props. (See fig. 36). There are two uprights 6 feet long, and on the top of these is a crown 10 feet long. These legs are set on soles 12 ins. × 5 ins. × 7 ins. The crowns are slightly arched, having a versed sine of about 6 inches; and

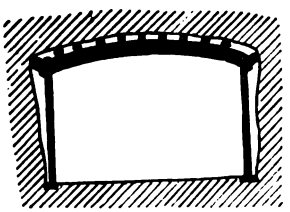


FIG. 36.—PENDLEBURY.

FIG. 36A.

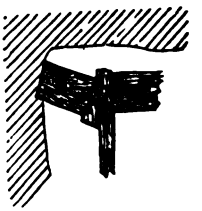


FIG. 36B.

there is a short prop, 6 ins. long and 6 ins. diameter, wedged in between the end of the rail and the side. These are put in every 4 feet for some distance along the level, and rafters are laid between the crowns. There is little or no timber in the level. The boundary has been altered and the level extended, and at the place where it stood the roof is tender and props and gears are put up, but no where else. The level is driven 20 yards wide. The road is 9 feet wide, and there is an 8-yards pack with a 3-yards air-course to the rise, and a 6-yards pack and a 2-yards air-course to the dip.

The following is the section of the seam at the face (see fig. 37): —There are 4 ins. of inferior coal left on in the working, but taken

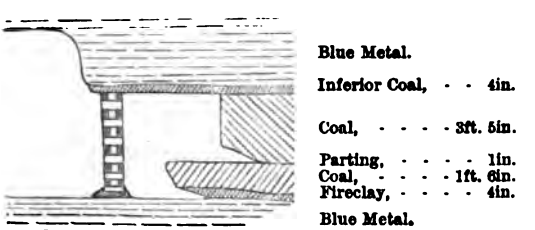


FIG. 37.—PENDLEBURY—RAM'S MINE.

down in the road. Above this are 7 yards of blue metal, 3 feet of which are taken down in the road. The floor is blue metal. In working the coal it is first holed in the middle and the top coal

taken down and kept 3 feet in advance of the bottoms, which are blown up with a shot. The shots are fired by a competent person. In some places there is 4 ins. of daugh, and the seam is holed in this. Short sprags, 18 ins. long and 6 ins. high, are put in, with wedges on the top. In the sample place (fig. 38) there were two

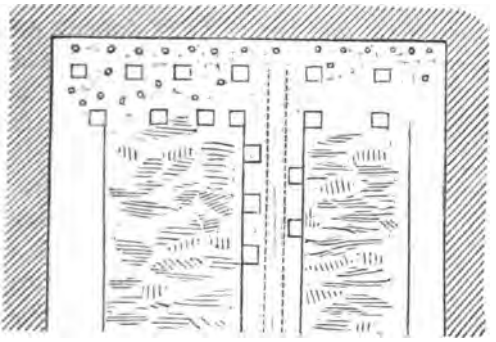


FIG. 38.—PENDLEBURY—RAM'S MINE—PLAN OF FACE OF LEVEL.
(Scale—1 inch = 33 feet.)

rows of 2 feet chocks, 2 chocks in the line on the dip side and 4 on the rise side. These were put 6 feet apart, and as the face advanced the last row was drawn out and put in front. In the face the last row was being withdrawn, and in order to do this props were put all round the chock to be withdrawn. These were taken out afterwards. In the face there were 12 chocks and 31 props 4 ins. diameter and 5 ins. long. The props were set between the chocks, and there were 5 chocks on the road going out, 3 on the rise side, and 2 on the dip. These were put up 6 feet apart. The props and chocks are put in by the stall-man and taken out by the shot-lighter. The stall-man is paid at the rate of 7s 7d for 3¼ tons for coal and 4s 7d for 3½ tons small. This method of driving is said to be safer in a fiery field because it opens up the ground more slowly and allows the gas time to drain. We saw no pillar working in this place.

The roof was only moderately good, and the cost for timber was 2d a ton.

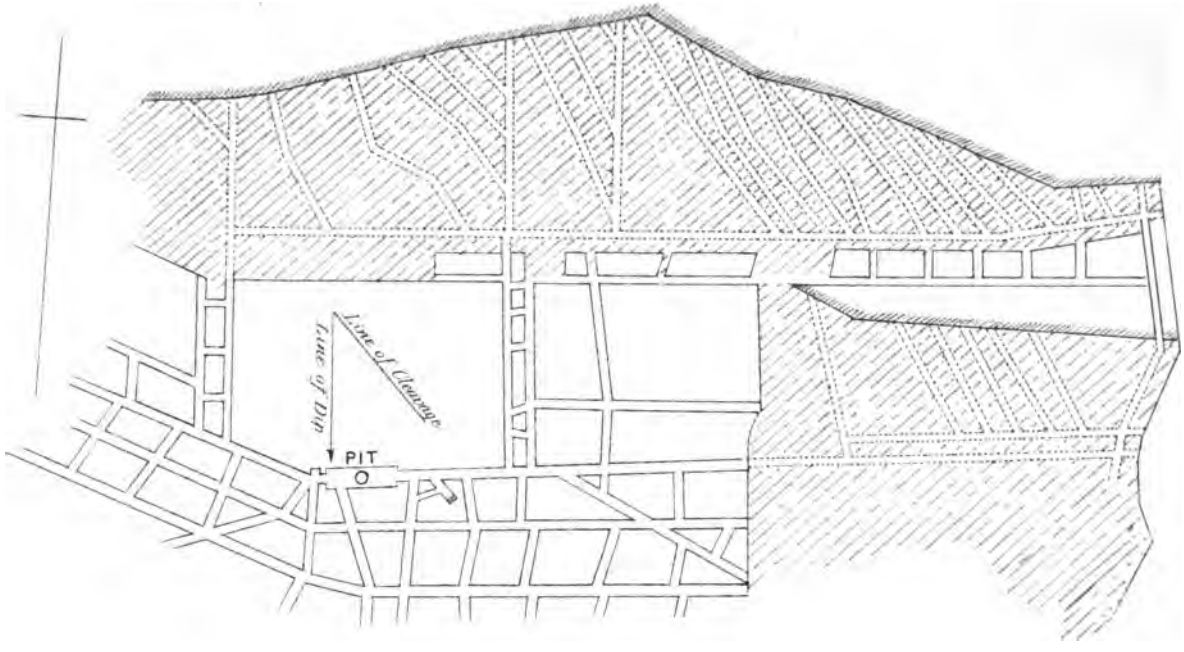
Thursday, 14th April, 1881.—SOVEREIGN PIT, West Leigh, near Manchester. Owners: Messrs Wigan Iron and Coal Co. (Limited). Agent: Mr Alfred Hewlett. Manager: Mr Jas. Hayes.

This pit has been in operation for three years and has worked the West Leigh 5 feet seam during this time. This seam is the same as the Wigan 9 feet and the Trencherbone at Clifton Hall. There are two pits, one a downcast 188 fathoms deep, and the other an upcast. The winding engines are a pair of high-pressure horizontal engines, 36-inch cylinders, 6½ feet stroke, with Cornish valves. There are flat wire ropes in the pit, and the drums are 15 feet diameter. The other pit is used solely as an upcast, and the ventilation is caused by a Guibal fan, 40 feet diameter and 15 feet broad. It is driven by a horizontal engine, 30-inch cylinder and 3-feet stroke, with Cornish valves. There is a duplicate engine, and each engine drives the fan 8 weeks alternately. The fan is driven at 35 strokes a minute, and gives 200,000 feet of air at 1·6 inches water gauge.

The seam is very fiery and is subject to sudden outbursts of gas from the pavement. This gas comes from a thin seam of coal 42 feet below the workings, and in order to let off the gas, boreholes are put down to this. At present there are two boreholes from which gas is issuing. There is a tube with two branches on the top of the borehole, and a pressure gauge was put on one of these. This indicated a pressure of 15lbs. to the square inch, and, when the cock was opened, the gas roared out like high-pressed steam. After letting the gas run for a few seconds the pressure fell 5lbs. on the square inch, but, on the cock being closed, it gradually rose to the original pressure. These boreholes are shut off while the men are in the pit, but after they are all out the fireman goes round and turns them on and lets the gas issue for about 10 hours till he makes his examination in the morning, when he shuts them off. The gas issues all Sunday, and on Monday morning the pressure is considerably diminished. During the time of the strike, one of the boreholes which was left open all the time became completely exhausted; but gas has since accumulated, and is now given off at it. The roof is also full of gas, and whenever a fall takes place

PLAN OF PART OF SOVEREIGN PIT.

Reduced from Working Plan.



Scale.

Feet. 100 50 0 100 200 300 400 500 600 Feet.

large quantities are given off. This gas is much more explosive than the ordinary firedamp, and it is almost impossible to get a cap with it. A mixture with air with 3 per cent. of firedamp in it is explosive when heavily charged with dust. All the men use Mueseler safety lamps.

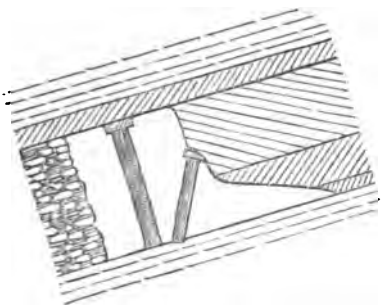


FIG. 39.—SOVEREIGN—WEST LEIGH FIVE FEET SEAM, SHEWING PROPS AND SPRAGS.

The seam dips at an inclination of 1 in 6. The workings are by the long-wall method, and the roads are 12 to 20 yards apart—levels being driven every 80 yards. A plan of part of the workings is shown on Plate XVI. The coal is 4 feet thick (see section, fig. 39) and above this are 10 inches of inferior coal, which is left on for a roof. Above this are 19 yards of laminated shale which is very tender, and if worked narrow work would have a tendency to break down in gutters, and make a bad roof; but, when worked long-wall, it makes a good roof. Under the coal is 2ft. 3in. of blaes, and below this is fireclay 4in., then 2ft. fireclay and blue metal, then 42ft. of blue metal with bands of coal, and then the thin coal to which the boreholes are put down. In the working the 2ft. 7in. of shale and fireclay is taken out along with the coal. The 4in. of daugh is used as a holing, and the blaes is taken down in front to give height. Sprags 5ft. 3in. long and 6in. diameter are used to support the coal while this is being done. When it is in 6ft. the sprags are knocked out and the coal falls. The shale is built into pack walls at the side of the roads, and the whole space between the roads filled tight with the rubbish. There is no brushing; and the roads are left further apart than 12 yards

if there is too much rubbish. When the roads sink and are too low, a level is driven through the stow to cut them off. It is found better to drive the level through the waste than to make it along the face, because, the roof having settled in the waste, they have less trouble to maintain the road. The roads to the face are not driven at right angles to the level, but on a slope, so as to make the gradient easier for the hutches; but there is one place which is always kept at right angles to the level and used as a "jig brow." There is a chock kept in the pointed end of the building at the face. In the sample place there were sprags every 4 feet and props in between the sprags, and at the roadhead there were 2 chocks 8 feet apart. There was a space of 15 feet at the head of the roadway without a sprag. Down the road were 4 sets of props and gears set at about 3 feet apart down to the first chock, which was 16 feet from the face in the line of the road. There was no other timbering in the roads. The sprags were 6 inches diameter and 5 feet long, and we noticed some with an iron ring 1·75in. broad, and $\frac{3}{8}$in. thick on each end to prevent them splitting. These were found to last much longer, but were only being tried as an experiment. We were informed that one blacksmith had put rings on 30 in a day's work.

There is a collier in each 10 yards wall. He employs a drawer and holes the coal, puts in sprags and turns over the rubbish and sends his coal to the bottom of the jig brow, and for this gets 1s 4d a ton for round coal and 1s for dross. There is 95 per cent. of round coal. A collier puts out on an average 7 tons in a day of 9 hours. He takes nothing to do with the building of packs or putting in the chocks. This is done by special contractors, who are paid 6d a ton for putting in packs, setting and drawing the props and chocks. They take charge of the roads from the pit-bottom, and work both night and day. Four-fifths of their work, however, is done during the day. There are two pairs of contractors in the pit, one pair to each set of faces. Each pair has 18 or 19 men who look ofter a face of 700 yards. There is a man to every 3 colliers. 85 per cent. of the faces are working on end. There are 74 colliers in the pit for 400 tons a day—55 of whom have a drawer, and 21 draw for themselves. They begin at 5 in the morning and go out at 3.30. There is one

overman in the pit; there are 7 horses. The strait work at the bottom is found to be very difficult to keep up. The cost for timber at the face is ½d per ton--the price of ordinary propwood at the works being 9s 8d per 100 lineal feet, and 1s 3½d per cubic foot for larch. The roads are dry but not dusty.

EASTERN DISTRICT OF SCOTLAND.

The special rules as to propping are :—

7. The Oversman shall see that a plentiful supply of Timber, for props and other purposes, required by the workmen to carry on their operations with safety to themselves, is always ready; and shall cause the same to be cut in proper lengths, and laid down in the working places as provided for in Rule 28.

26. The Roadsmen shall also lay rails in the roads, where requisite; and, in the absence of the Manager or Oversman, they shall receive all reports or communications from the Miners, and other workmen, as to falls and defects in the roads, roofs, and buildings, and shall proceed to, and repair or remedy, the falls and defects.

28. It shall be the special duty of the Roadsmen, in their different divisions, if more than one, to observe that an adequate supply of Timber, for props and other necessary purposes, is always ready at the place where the Miners are at work, for the use of the Miners, in supporting the roofs and sides of their working places, and to report to the Manager or Oversman if they shall observe any want of such timber. For the purpose of carrying out this Rule, Roadsmen are empowered to call upon Drawers, Putters, and Drivers, whether employed by the Owner or Miner, to convey such necessary Timber from the Pit-bottom, or other place of general delivery, to the working places in connection with which they are employed.

40. It shall be the Fireman's duty to see that the Miners are attending to the security of the roofs and sides of the working

places, and for that purpose to visit each working place at least three times each day at proper intervals; and in case of finding that any Miner is failing so to secure his working place, by propping the same, or otherwise, to point out to such Miner any such failure; and should such Miner refuse or fail to perform such repairs as may be necessary to render the place secure, to require him and his assistants to remove from such working place. Besides the periodical examination already provided for, it shall be the duty of the Fireman, when applied to by any Miner, stating that his working place is, in the matter of propping, in a dangerous condition, which requires the intervention of a skilled person, to proceed to such working place, examine the same, and cause such remedies to be applied as shall appear to be necessary for the safety of the place, the Miner himself assisting in any necessary operation.

58. Whether the operations shall be conducted by the "Long Wall," or "Stoop and Room," system, a sufficient number of suitable props being supplied at their working places, the same shall be set up by the Miners in their working places where the roof and sides require to be secured by them, in terms of General Rule 16. These props and any necessary sprags or gibs shall be set up at such times, in such number, and at such points within the working limits as shall, from time to time, be necessary.

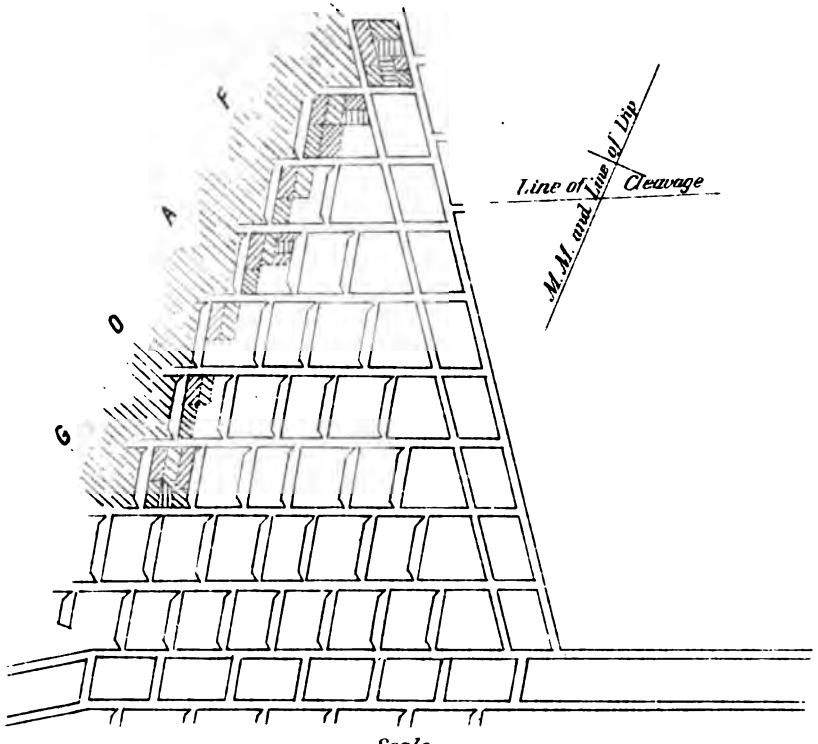
59. But, besides being bound to prop and secure according to their own skill and experience, Miners are required to place props within their working places in such a manner as the Fireman, or other person authorised to that effect, shall deem necessary, and shall direct, for the safety of the Workmen and the Mine.

60. When employed to return upon and remove stoops left in any seam, Miners shall be bound to prop and secure the roof and strata around each stoop before commencing to cut or remove the same, and such places shall be deemed "working places" under these Rules.

61. If, from accident or any other cause, Miners are at any time unable to find a sufficient supply of prop-wood at the place appointed, they are expressly forbidden to remain in their working places.

PLAN OF PART OF ALLANSHAW COLLIERY.

Reduced from Working Plan.



ALLANSHAW COLLIERY, Hamilton. Owners: Allanshaw Coal Co. Manager: Mr Joseph Park.

This colliery has been working for the last five years. There are two shafts, each 13½ feet diameter,* and 117 fathoms deep. Only the downcast shaft is used for winding, although there is upon each a pair of horizontal, high-pressure winding engines, 26 inch cylinder and 5 feet stroke. One hutch holding a ton of coal is raised at a time. The ventilation is caused by a Guibal fan, 20 feet diameter, and 5 feet wide. This is driven at 40 revolutions per minute, and gives 40,000 feet at a water-gauge of half an inch. The output is 450 tons in a day of 10 hours.

The seam worked is the ell coal, which is 7 feet thick. It is worked by the pillar and stall method (see plan, Plate XVII.), the pillars being 20 yards wide and 30 long. The places are 9 feet wide the short way and 12 feet the long, which is facing the cleat. The dip is 1 in 20 to the north. The sample place in the solid workings was 12 feet wide and 20 yards in. A row of trees was set up on each side of the roadway, the trees being 5 feet apart. These were put up by the miner, and must be put in every 5 feet whether the roof is good or bad. The trees were 4½ inches diameter at the thin end, and cost 7s 3d for 100 lineal feet. Two men worked in the place. The coal is first holed, then shorn on one side, and then a shot is put on the other, and the coal is blown down. Naked lights are used in the solid places, and the shots are fired by the men themselves. They are paid so much per ton of coal and dross, and have no extra payment for timbering. The section (fig. 40) was as follows:

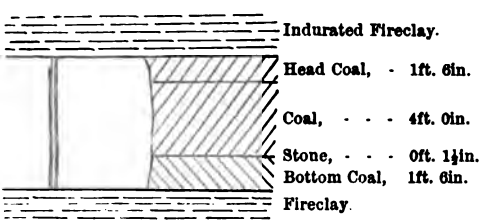


FIG. 40.—ALLANSHAW ELL COAL.—SECTION OF FACE.

* Although these shafts are circular, almost all the pits in Scotland are rectangular and divided into two and sometimes three compartments, one for each cage and the third for the pumps.

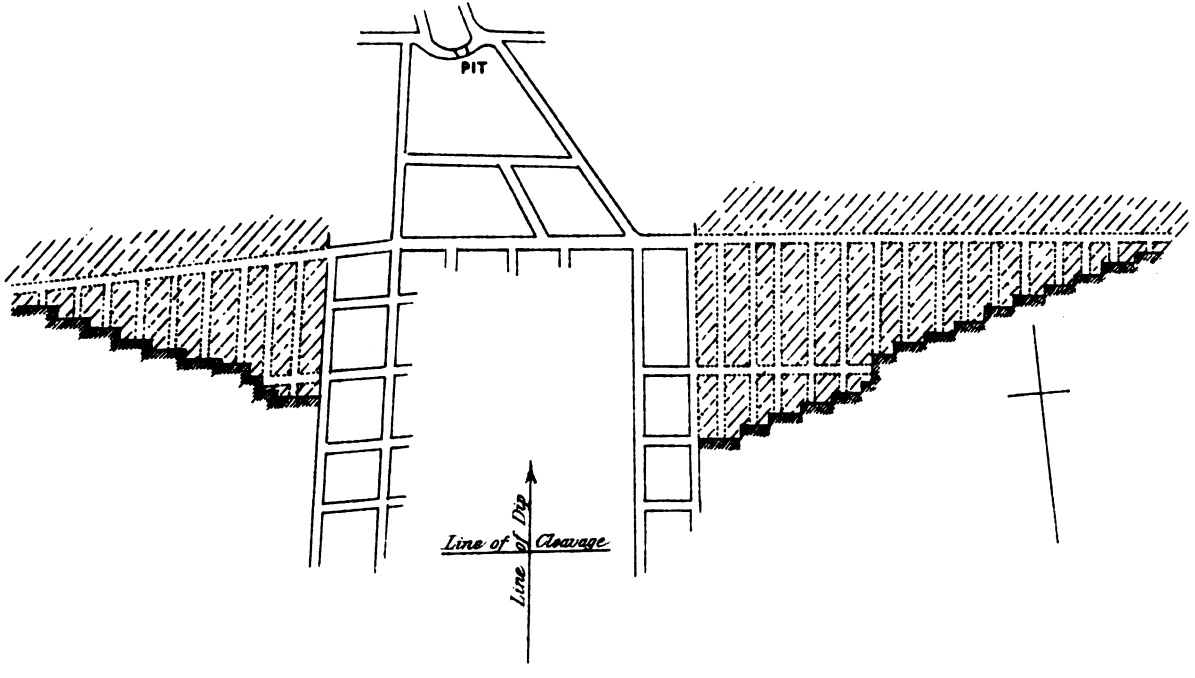
—The coal was 7 feet thick. There were very bad partings from both roof and pavement. On the top of the coal was 4 feet of indurated fireclay, and then 20 feet of rock. The pavement was fireclay, which was 6 feet thick. The pillars are worked off in lifts of 5 yards. The sample place was the first lift and was up 13 yards. There were three men in it, and they hewed and filled the coal into the hutches and put up all the timber. The men at the stooping used "Scotch gauze" lamps, and no powder is allowed to be used. The rails were laid 3 feet from the coal, and a line of props, 3 feet apart, were put in between the rails and the coal. Between the rails and the goaf there were lines of trees, 7 trees thick, running parallel to the face. There were 13 of these rows, 14 inches apart, between the side of the pillar, and, 17 feet back from the face, and from that to the face there were only 4 trees in each row. The reason of this was that the men generally got two hutches at a time, and after filling one, tumbled the empty one over on its side, so as to let the loaded one pass, and then drew in the other hutch to the face. The space was used for doing this. The trees were 4½ inches diameter and were put up with a small lid, 6 inches square and 1 inch thick. There were 150 in the sample place, and when the lift was its full length, 18 yds., there would be 300 props in. The props were drawn by the fireman in the afternoon, after he had completed his examinations, in terms of the General and Special Rules. There are three men drawing timber from a lift—two strike out the trees with a hammer, and the other puts them on a small truck and wheels them out to a place of safety in the drift. It takes about three hours to draw the wood from a lift where there are 300 trees.

COWDENBEATH COLLIERIES. Owners: Messrs the Cowdenbeath Coal Co. Managing Partner: Mr Henry Mungall.

These collieries have been working for the last 30 years, and at present operations are carried on at three shafts, viz., Nos. 3, 7, and 8. For the purpose of ventilation, No. 3 Pit is the upcast and Nos. 7 and 8 are the downcasts. Nos. 7 and 8 Pits are within

PLAN OF PART OF COWDENBEATH COLLIERY.

Reduced from Working Plan.



120 yards of each other, but No. 3 is a quarter of a mile from them. In form, all the pits are rectangular, No. 3 being 14ft. × 5½ft.; No. 7, 17ft. × 10ft.; and No. 8, 14ft. × 6ft. No. 3 Pit is 108 fathoms deep to the Dunfermline splint coal; No. 7 Pit, 135 fathoms to the same seam; and No. 8 Pit, 90 fathoms to the Lochgelly splint and parrot seam. The ventilation is caused by a Guibal Fan, 24ft. diamater and 8ft. broad, placed at No. 3 Pit. It is driven at 60 revolutions per minute, and circulates 50,000 cubic feet of air at a water gauge of 1·3in. There is heavy pumping machinery at Nos. 7 and 8 Pits; that at No. 7 pumps 800 gallons per minute, and that at No. 8, 600 gallons. Coal is drawn by all the shafts, the total output being about 800 tons per day. Presently the Dunfermline splint, 4ft. 6in. thick; Five feet, 4ft. 8in.; Mynheer, 4ft.; and the Lochgelly splint and parrot seam, 12ft. thick, are worked at No. 7 Pit. The seams rise to the south at an inclination varying from 1 in 6 to 1 in 3, and are worked by the long-wall method. In the Dunfermline splint seam, the levels are driven on end, or almost parallel with the line of cleavage. The faces are worked on the plane, the roads being branched off every 14 yards, and are driven up 60 yards when they are cut off by cross roads or levels coming across the faces. (A plan of part of the workings is shewn on Plate XVIII.) The coals are

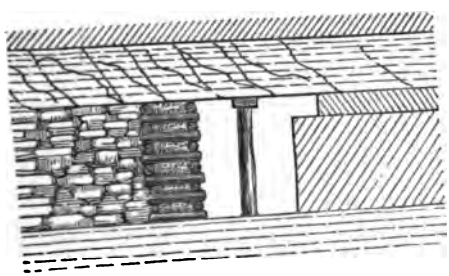


FIG. 41.—COWDENBEATH—DUNFERMLINE SPLINT.

drawn from the faces to wheel braes by the men, thence by self-acting inclined planes to the shaft; cut chains being used to let

the coals down from the top levels to the main wheel braes. The roof of this seam is very bad. In the sample place the seam was 4ft. 10in. thick (see section, fig. 41), and immediately above this was 15in. of "Cash," or soft shale, which the miners holed in. Above this the roof was shale, for 12 feet in thickness, and then rock. The pavement was freestone about 6 feet thick. On account of the heavy roof above this seam, it was found better not to keep the wall faces in a straight line,

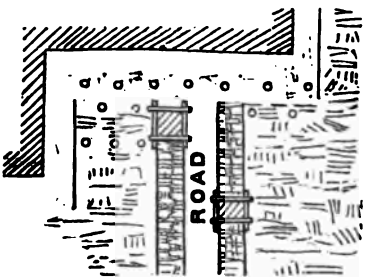


FIG. 42.—COWDENBEATH—PLAN OF WORKING FACE.
Scale—1 inch = 33 feet.

but to step them 5 yards in advance of each other. (See fig. 42.) By these means the weight was confined to the limit of each wall, and a more gradual settling down of the roof secured. Two men worked in this place, and they put up all props, chocks, buildings, and hewed the coal. They put out about 5 tons a day of 8 hours, and were paid 2s per ton of round coal for doing so. No powder was used in working this seam. There was no rule fixing the distance between the props; the men put them up where they considered them necessary, and where ordered by the fireman. Very few of the props were got out, as the roof was very bad, and the men thought it dangerous to draw them. The props were 3½in. diameter, and were put up with lids made of broken props. Chocks 6 feet square, formed of props and filled inside with rubbish, were put on the sides of the roads, as the "cash" or soft shale (which the miners holed in) made but a very poor building. These chocks are taken out when the roads are abandoned. The firemen in the pits did not put up the props, but directed the workmen

to put them up if they saw cause, and for this purpose they made three visits into each man's working-place during his shift. The main roads were timbered with props and gears, not placed at any specified distances but where considered necessary. The roof was a bad one and required a considerable amount of timber. The cost of timber was 5d per ton of round coal, and wood cost 5s per 100 lineal feet at the pit.

TABLE *showing the Number of* Lives Lost *by Falls of Roof and Sides, and the Quantity of Mineral Raised in Tons per Life Lost, in each of the Districts of Inspection in the United Kingdom, from 1873 to 1880:—*

	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.
Northumberland, Cumberland, and North Durham, ...	48 287.026	27 520,716	24 598.638	35 415,937	32 426,602	32 411,615	23 583,043	27 590,415
S. Durham, Westmoreland, and N. Riding of Yorkshire, ...	43 542,710	31 769,181	48 541,293	49 540,690	47 556,330	44 549,290	38 580,255	43 646,228
N. and E. Lancashire and Ireland,...	38 213,727	31 266,892	40 227,596	24 357,525	22 408,788	35 252,636	31 296,996	44 221,912
W. Lancashire and N. Wales,	42 247,062	41 243,338	62 184,854	61 189,960	47 245,145	54 217,955	47 252,677	43 282,119
Yorkshire, ...	53 297,447	49 311,565	62 264,443	37 424,517	59 277,472	40 404,704	41 407,567	64 296,406
Derbyshire, Nottingham, Leicestershire, & Warwickshire,	39 302,353	26 481,730	27 468,254	46 271,762	30 435,718	31 437,913	26 544,010	35 417,807
N. Staffordshire, Cheshire, and Shropshire, ...	32 290,417	31 300,398	23 362.692	19 398,510	19 424,962	31 253,059	20 359,557	26 291,400
S. Staffordshire and Worcestershire, ...	35 332,958	17 529,704	39 279.880	34 308,444	47 210,290	32 292,029	31 310,969	17 590,261
Monmouthshire, Gloucestershire, Somersetshire, & Devonshire,	39 181,280	40 179,468	33 195.070	30 246,269	31 233,870	45 162,914	48 157,456	31 269,319
South Wales, ...	64 185,649	53 221,955	46 223,362	54 222,267	53 224,325	62 197,698	68 185,622	71 218.826
Eastern District of Scotland,	35 322,917	34 330,732	28 453,975	38 344,901	35 373,764	36 363.914	28 456,709	30 456,517
Western District of Scotland,	23 365,818	33 250,394	26 348,736	22 409,355	26 342,729	27 303,821	25 326,008	31 270,916
Total Number of Lives Lost,	491	413	458	449	448	469	426	462

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 14th JULY, 1881,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

RALPH MOORE, Esq., President, in the Chair.

THE Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members :—

JOHN DUNN, Coalmaster, Bothwell.
ALEX. THOMSON, Coalmaster, 95 Bath Street, Glasgow.
WILLIAM FRASER, Manager, Uphall Mineral Oil Co., Uphall.
JAMES ROBERTSON, Colliery Manager, Braehead, Baillieston.
ROBERT COOK, Colliery Manager, Halbeath, Dunfermline.
JOHN HART, Colliery Manager, Clyde Iron Works, Tollcross.
JOHN ALLAN, Manager, Garturk Colliery, Coatbridge.
HUNTER BOWIE, Underground Manager, Lugar Iron Works, Old Cumnock.
ARCHIBALD KERR, Contractor, 21 John Street, Hamilton.

Other seven gentlemen were then nominated as Ordinary Members, and will be balloted for at the first meeting.

STIRLINGSHIRE COALS AND OTHER MINERALS.

BY MR PETER M'BETH.

STIRLINGSHIRE does not stand out very prominently as a mining county; yet, its mining operations have not been begun of recent date, as it is upwards of a century since Carron Ironworks were first established in the shire, and some of its mineral fields have

been productive for a considerably longer period; and although the fields are not what could be called very extensive, yet, though they have been wrought for such a lengthened period, they are, nevertheless, very far from being exhausted. I may mention that in the contiguous counties of Linlithgowshire and Lanarkshire the mineral sections have a very marked general resemblance, although they may differ somewhat in minor details. For the purpose of illustration, I have sketched on the accompanying sheets—in a column parallel with the vertical section of Lanarkshire as prepared by R. Moore, Esq., M.E., Glasgow, in 1854—a section of Stirlingshire minerals, and in doing so I have made extensive use of the very lucid, and generally accurate sections published by the Ordnance Survey Office, Edinburgh, 1877, as arranged by Mr Peach. I have followed his lines so far as we agree, and supplemented his information by that gathered from equally reliable sources, picked up now and again during the time such matters had my attention, and, let me add, that from whatever source information has been obtained, there has been no breach of trust in its communication; and should any of our present work meet the eyes of any of the original communicators, I hope they will accept our thanks for their frankly given information.

The first coal we find on the sheet, about 7 fathoms from the surface, is got in the Coneypark Coalfield in the eastern portion of Kilsyth Parish, covering an area of a few hundred square yards, and which I have placed opposite Lanarkshire Upper 4 feet coal. Next we have what was locally termed "Coneypark 14 feet"—apparently two or three coals come together. A portion was left for a roof when it was wrought, now many years ago. Then there was a fireclay, and below it a 4 feet coal which, possibly, might come in for the Ell, Pyotshaw, and Main Coals. We get also 4 coals below this—3 of which may be taken to represent the Humph, Splint, and Sour Milk Coals. At about 80 fathoms a coal 1 foot 6 inches comes in which may represent the Mussel Band Coal, though it differs from it in quality. We find only the position of the Airdrie Black Band—it is awanting. I may remark, all the coals mentioned have been mostly wrought out, and their positions only occupied the limited area already

mentioned, of a few hundred square yards. This limited area is, in mining phrase, the highest and only known area of the kind in Stirlingshire. We come now to a more widely diffused coal, whose position occupies a much more extensive area. At 88 fathoms, we get the Five-quarter, as so termed at Coneypark and Banknock, the Diamond Coal of Shieldhill and Blackbraes, and the Johnstone Coal of Slamannan. It varies in thickness; in some parts it is 2 feet, and in others it has been found upwards of 4 feet. It is now exhausted in the shire except in a portion of the Slamannan district. In some parts it is a very good household coal. It might with propriety be termed a landmark coal; it is undoubtedly the Virtuewell coal of the Monklands. Below it is got the Lady Grange coal in the Slamannan district from 2 feet to 2 feet 8 inches, where only it has been wrought to any extent. Next we get the Shieldhill Miller's Coal,—termed at Banknock the "thin coal," where it has been wrought for upwards of 30 years; but it has not been much wrought anywhere else in the county. The Bellside Blackband Ironstone position is got, but no ironstone of consequence yet. We come now to a coal that extended in the Banknock and Coneypark basin over an area of about two miles in length by about three-quarters of a mile in breadth with an average thickness of 6 feet, locally termed the "main coal," almost wrought out at these places; but the same coal is at present being wrought by Carron Co. at Carronhall, where its local name is the "craw coal," with a thickness of about 3½ feet. It has some features similar to the one we have placed it opposite in the Lanarkshire section, namely, the Kiltongue. Its position occupies a very much more extensive area, but I am not sure that anything of consequence is to be got anywhere in the shire than in places above. I have searched carefully the field where I am engaged about, and find its position easily; but all that I have fallen in with representing it is a coal about 7 or 8 inches with the orthodox parting of fireclay and an inch or two of coal below it. We come next to a coal more widely diffused, with a thickness of from 2½ feet to 3 feet 4 inches, and in some instances even more. This is the main coal of Carronhall and Grangemouth, the splint coal of Callander, Shieldhill, Redding, Blackbraes, Bowhouse, Muiravonside, and Candie; and the steam

coal of the Slamannan district. Much of this coal is at present wrought in the shire, and although some fields are all but exhausted, still there are extensive areas that have not yet been touched. It is in general a coal of good quality; in some places it is a good coking coal, and in others it is a high-class steam coal. Next we find the Little Splint or Shieldhill district "mid-coal," in some places about 20 inches thick, but has not yet been much wrought. It is often got not above 10 or 12 inches thick. Our next in the section is the Coxroad coal, generally from 2 to 3 feet in thickness, although in some instances more. This coal is also well developed over the eastern and southern districts of the shire, covering an area, roughly put, at something like 30 square miles or upwards. Although variable in quality, it is generally a good household coal; in some cases it is the best house coal in the section. The next that has been wrought is the Balmoral coal or Low Coxroad, about 2 feet thick, which has only been wrought in the Slamannan district. We next come to what we may term the first pronounced ironstone met with, consisting of about 4 inches of clay band and about 6 inches shelly blackband ironstone, with 8 inches of a sort of parrot and 14 inches rough coal below it. It is locally termed the Auchengean or Shotland coal, and was wrought some years ago by Carron Company. Below this we find a very good sandstone, the same which has been wrought at Brighton Quarry, a little hard to work, but a fine looking stone, and stands the weather well. Below it is the Brighton main coal, 5 feet thick, with two ribs of stone in it; it is of a coarse quality. About 5 fathoms below it we have a coal about 4 feet thick, with ribs of stone also, greatly against its commercial value. These coals have been little wrought, and extend over a very much wider area than any we have referred to. The last mentioned coal is locally called the Gutterhole or Glenfuir, extending with scarcely a break or want from the Firth of Forth to the Blackloch, and from Redford to the west of Camelon. About 10 fathoms below the above position is met with what is termed the Bonnyhill upper stone or clay-band ironstone, with fireclay and 12 inches of coal below it, and 4 fathoms further down a sulphurous coal 12 to 15 inches, termed the Bonnyhill craw coal. Below this again comes in about 6 inches of iron-

stone balls, technically called the Bonnyhill ballstone. This and the ironstone above was many years wrought by Carron Co. It sometimes assumes the appearance of a regular band, and when this occurs it gets sulphurous in nature, and by some is termed the "Sulphur Band." I may add that some who ought to know well its position reckon it the "Upper Slaty Band," and consider it to be the same as is wrought at Loanfoot on the Callander estate, by Messrs Addie & Sons. About 4 fathoms or so below this we have the position of the "Lower Slaty Band" ironstone. It was discovered in the year 1851, in the lands of Lochgreen. It was many years wrought at Sauchierigg and Tippetcraig. It varied in thickness, being met with from 12 inches up to 5 feet thick. This position has been often tapped in various parts of the shire in search of this mineral, as well as of that other, the "Torbanehill Mineral," which ought to have been in this region, but however desirable the acquirement of either of those might have been to many, it is evident they are both rather capricious, for although their positions occupy a very much wider area than any of the minerals we have hitherto referred to, only at places above mentioned has the lower slaty band been wrought. Below this, for a considerable distance, we are very barren and bleak in aspect, even the very surface participates in the sterility of the mineral section. The Moor Rocks occupy in some places in Stirlingshire, where they have been pretty well determined, a thickness of the section of no less than about 100 fathoms, composed mostly of gritty, lithy sandstones, interspersed by a few sulphurous coals and a number of layers of fire-clay. Entry on this section of the strata is now looked upon by many, in the present state of things, as an unfortunate termination to their prospects, for good sums of money have been spent at various points to try and develop several of the coals that occur at different points of the section, but hitherto all attempts have proved abortive. Recently, however, a slight ray of hope seems to beam from this hitherto clouded region, as at the coal 18 inches thick, about 20 fathoms below the lower slaty band, a substance called gainster is found below it, from 2½ feet to 3 feet thick, which seems valuable for ironworks, and is in much request for certain purposes about them. It is wrought at the Drum Fire

Brickworks, south of Bonnybridge Station, and has contributed to make these thriving little works. Nothing worthy of note is met with till we get to the Roman cement about the bottom of the Moor Rocks. It is from 18 to 20 inches thick, effervesces pretty freely when tried with acid, but has not been wrought yet in the shire. About 5 fathoms below it we get the Castlecary or Levenseat limestone about 7 feet thick. It has not been much wrought in the shire. A very good limestone for building and agricultural purposes, and very suitable for iron smelting. About 5 fathoms below it we get the Netherwood freestone rock; an excellent building stone, easily wrought, and resists the action of weather well. 45 fathoms below this is a clay-band ironstone 6 inches thick, which was wrought 60 years ago at Glendawson, adjoining the shire, for the Carron Ironworks, but has been no way wrought in the shire. We next get 2 inches ironstone, but nothing of consequence is got till we reach the Netherwood calm limestone—the Garnkirk of Lanarkshire, widely known as the Arden limestone. 6 or 7 fathoms below this we reached the position of the Netherwood Upper Coking coal, 30 inches, and a few feet further down the Netherwood Lower Coking Coal —better known respectively by the Hirst Thick Coal and Hirst Fine Coal. These coals, the lower especially, made excellent clean coke; when burning they had a powerful heat but not much flame, and were in great request for bottle works. They have never been wrought, I may say, in the shire, although on the immediate boundary, and it is well enough known they extend so far at least into it. It is somewhat singular, with regard to these coals, that wherever they have been fallen in with at any other places, they have always been got in the state of anthracite. About 40 fathoms or so below the Calm Limestone (Netherwood) the "Denny Rough Limestone," some places 3 feet 10 inches thick, is met with, its equivalent in the Lanarkshire section being the Cowglen. It is better known by many in the Stirlingshire district as "Major Orr's," or the "Dykehead Limestone." In nature it is a kind of hybrid—half rough, half calm; was wrought to a slight extent, and suited for ironsmelting and agricultural purposes. Wherever it has been mined, it had one great mining drawback, namely, a bad roof. The next thing of importance we notice, about

32 fathoms or so below the "Index Limestone," or "Denny Limestone," is the "Denny Upper Blackband Ironstone," 9 inches thick, —same as Possil, a high-class blackband. Next comes in the "Lower Blackband," which is got 7 inches thick in some places. Taking the following contiguous coals, which are considered the positions of the respective Bannockburn coals,—we may be allowed to remark, with reference to some of the coals got in this part of our section, that they have turned out as fortunate speculations for those connected with them as any minerals to be got in the section, chiefly owing to their fine coking qualities—some of them being productive of the best coke in the shire. In fact, some of these coals wrought in the shire, or immediately adjacent thereto, are launched on certain markets under the name of "English Scotch Coal." Below this, in some parts an intrusive whin has been met with, variable in thickness, possibly in some places it might not be got; and then below it has been found the Clayband Ironstones of Castlerankin, as detailed on the section, Plate XIX. These were wrought many years for Carron Ironworks. Below this position is got the Banton Ironstones and Coals, which have been long wrought—one of the coals being famed for smithy purposes. We have gone roughly over the most inviting minerals in our section, when we refer to the Campsie Limestone, which I need scarcely add is considered to be the position of the Hurlet; it is a limestone much used for building and agricultural purposes. Having gone hastily over the general features of the section, it may scarcely be necessary to add that all the minerals, as detailed in the section, are not invariably got as they are placed. Often in contiguous fields may be found a very marked and important difference. On separate sides of a slip, or fault, a material difference in the thickness of the coals and other minerals, as well as the intervening strata, may be met with; even a very important alteration in their respective qualities, and sometimes a considerable portion of the vertical section may be awanting altogether. We may be allowed to remark that, as to the extent of the lower coal series, owing to the great depths that prevails, much of the knowledge concerning it is matter of speculation, and must remain so, till borings or sinkings demonstrate its real contents.

The PRESIDENT—As one who has dabbled a little in these

matters, I can tell you I have listened to this paper wit
pleasure. I have not heard a more lucid statement for a lo
I am very much obliged to Mr M'Beth for taking advant
the hint that we should have more papers on stratigraphy.
this beginning will tempt some of you to do something
same.

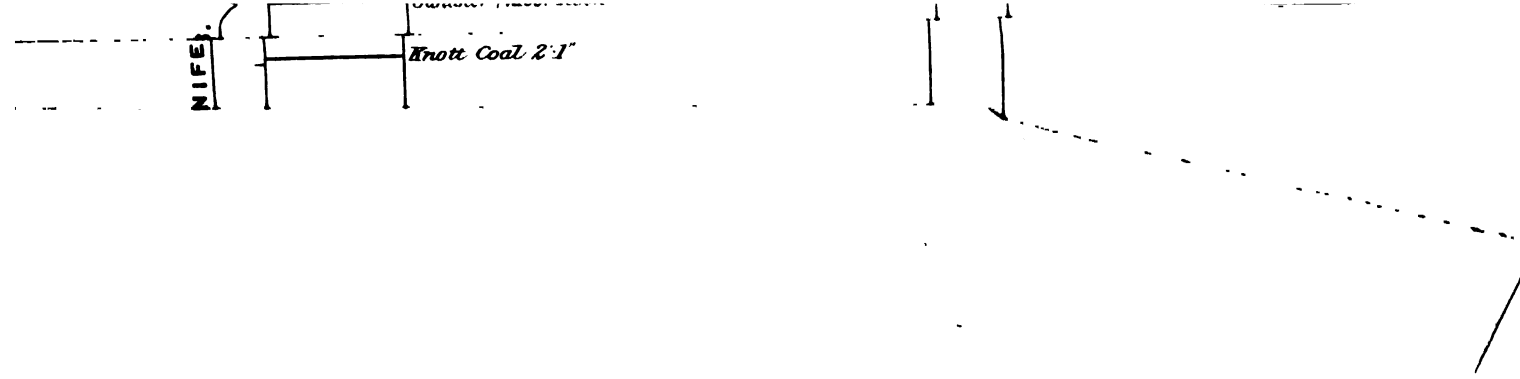
THE SAFETY LAMPS AND ELECTRIC LIGHT.

The SECRETARY—I may inform the members that the C
mittee appointed at last meeting have not had an opportuni
testing the Safety Lamps on which they were to report. H
ever, this is perhaps not of so much importance, seeing that
Crossley, whose lamp has never been discussed, could not be pre
to-night. The committee expect to be prepared with a re
for next meeting. As to the electric light at Earnock, we fu
expect it will be burning on Tuesday or Wednesday. I may
that Mr Watson intends to invite the members of the Institute
come and see the light after it is fairly started.

THE REPORT BY THE DEPUTATION ON THE VARIOUS MODES OF SUPPORTING ROOFS AND SIDES.

The PRESIDENT—The next business is the discussion, or rather
any questions which you may think it necessary to ask regarding
the report by the deputation on the different methods of support-
ing the roofs and sides. I see two of them are here, and, I
suppose, they will be very glad to answer any questions as far as
they can.

Mr BEGG—To set the discussion agoing, and to begin at the point where the deputation started, I would ask the members to turn to p. 53. The deputation say:—"Upon the whole matter" (reads). Now, I must say that my opinion when the deputation was appointed was strongly in favour of the system of propping by deputies, instead of the hap-hazard method followed at present. I was also hopeful that the investigations of the deputation would bring out a strong recommendation from them in support of this


NIFE).
Knott Coal 2'1"

opinion, and, therefore, I cannot but express serious disappointment; but, before quite adopting the opinions of the deputation, I would like them to show us from the detailed account of their visits to the different collieries the facts on which they have based their opinion and their recommendation, because it is really going to the root of the subject they were asked to investigate. It is quite possible it may all be in the paper, but I have not had time—and I do not think the other members will have had time either—to thoroughly master the report.

Mr DRINNAN—I have to confess that I started on my trip with rather a different impression with regard to setting the props by deputies than Mr Begg appears to have entertained. Therefore, I had no preconceived notions on the subject to be got rid of, and I was guided very much by what I saw in these pits where the propping was done by deputies and where it was not done by deputies but by the miners themselves. Indeed, I know that where it was expected to be done by deputies it was still done by the workmen, and there was nothing in these pits we visited where the propping was supposed to be done by the depnties—there was nothing in the setting of the timber, nor the apparent safety of the roads—that I consider would have justified the enormous expense that many collieries would be at if they were to cause the timbering to be done by deputies. It does not guarantee the men the safety that is expected by those who advocate that system, because if a deputy is really to attend, as a miner ought to be attended, to ensure the safety desiderated, there would need to be a deputy in every collier's place, because we know, as practical men, that a dangerous state of things might exist in a place one minute and not another. Then a dangerous state of matters might arise at one time and at that very time the deputy might be absent, and an accident might happen, the danger not being seen. I am scarcely prepared to go into the matter on the spur of the moment. I rather expected to wait till a number of questions were put and to reply to the whole, when I would have had a little time to condense my reply.

The PRESIDENT—I think it is only fair, whatever replies Mr Drinnan or the deputation make just now, that they should still be allowed to go back on the same subjects afterwards.

Mr ROBSON—I notice that the deputation have given a table at the end of their report. I would like to draw attention to the table, and to ask the deputation if they do not think it is brought out by these statistics that the districts where the deputy system prevails are the safest districts, and, if so, if that result is not rather against their general recommendation? I think it will be seen at a glance that the Durham and Northumberland districts are the safest; the next to these is the Derbyshire district where a system prevails similar to deputies, stallmen having charge of the setting of the props.

Mr R. T. MOORE—It is very difficult to explain the facts shown by the table, but in the last year's statistics it is shown that in the Staffordshire district, where Cannock Chase is situated, the number of tons of coal raised is very nearly as great as in Northumberland, where the deputy system prevails. Then Cannock Chase—the system which we have recommended—is thus shewn to be very nearly as safe as the deputy system in Durham, and the table only shows the quantity of coal raised per life lost. This would depend very much on the thickness of the seam, so that it could scarcely be said the deputy system is safer because a given quantity of coal is raised in a district.

Mr DRINNAN—There is just another point I wish to put right. Mr Robson made reference to the system whereby stallmen did the work. I have to say these stallmen are simply miners, simply contractors, and in no sense officials of the Company. It is the same as a man who in Scotland might contract to do a certain amount of work. They are called stallmen or butties, but do not differ from a miner other than being a contractor on a larger scale. Mr Moore has called attention to the points that account for the greater safety. The state of the roof would itself account quite satisfactorily to my mind for the greater safety there, because I did not see anything in the roof or sides that would be likely to cause frequent accidents.

Mr ROBSON—I should say the general circumstances must be pretty much the same in the one instance as in the other. You cannot say because one particular colliery has a good roof that that district would have generally good roofs. There must be good, bad, and indifferent roofs in every district. I certainly

think that the statistics do bring out, not only one year, but year after year, that these referred to are the safest districts.

Mr RONALDSON—Might the way in which the coal is got in this district not account for these seemingly good results in the North of England? Here the safety is based on the output which I think is not the correct way.

Mr ANDERSON—Is there anything in the number of tons that is put out by each man? It seems that the quantity is the test of safety. We know that amongst ourselves in some collieries a man will put out 30 cwt., and in some other places he will put out perhaps 4 or 5 tons. Will there be nothing exceptional in these several districts—I mean Northumberland and Durham—in regard to the greater quantity a man puts out? Will it be owing to the others not being so favourable in regard to the roof or wholly due to the system of the deputies putting up the props? If the deputation or Mr Robson know anything about that, they might let us know it.

Mr ROBSON—I do not think there can be anything in the roofs or coals, or in the quantity of coal put out per man, which can affect the question to such an extent as it is affected here. Seeing those statistics bring out year after year that there is a less loss of life per million tons raised, it looks as if the system has something to do with the result. It must be remembered that the system is not pursued in a small area, but that it is applied to mines producing one-fourth of the minerals raised in the kingdom, as may be gathered from the table referred to.

The PRESIDENT—Turn to page 55 where they describe a sample place. If that was the case, the roofs must have been very bad, for the system followed was to place props every yard—not only props, but gears.

Mr DRINNAN—Perhaps I may best answer the President's remarks if I were to say that it is not at all unlikely that the people there have followed out the Inspector's instructions that props and crowns should be put up at a regular distance, no matter whether the roof is good or bad. With regard to the question put by Mr Anderson with respect to the quantity of coal put out, members will find in the report pretty full information in regard to the output at all the places we visited. With respect to those

two places, the output is about 5 tons per man. He is paid 10d a ton for hewing and filling. You will be able to compare the output there with the output in other places where there is a greater loss of life. I cannot say in an off-hand manner what is the output. I know of some parts of Yorkshire where it is 2 tons and 2½ tons—that is a great deal less. With respect to that at Barnsley, the coal there is very much thicker than the parts of Yorkshire to which I referred. My knowledge is obtained from having worked at a colliery three or four years in the neighbourhood of Kiveton.

The PRESIDENT—I think we should confine ourselves to this one point that Mr Begg has raised, and it would be desirable that as many questions as possible on that subject should be put to-night,—viz., as to wherein consists the advantage of the system they propose over that which, according to their statistics, is the better? How does it happen with these things before them that they still recommend the present system?

Mr SMART—Mr Begg in the first portion of his remarks stated that he was very much disappointed with the result of the deputation's enquiries that the props should not be put up by deputies. Now, it has been generally understood that deputies were not required. Perhaps Mr Begg will explain on what grounds he thinks the deputy the best party to put them up from an economic point of view as well as for the safety of the workmen?

The PRESIDENT—That would rather complicate the discussion, Mr Smart. Mr Drinnan is quite able to hold his own.

Mr DRINNAN—I am only afraid that being called on to give an off-hand answer I may not be able to do justice to the question, —that is to convey fully the reasons I had; but I will endeavour to answer every question at the moment, taking advantage of the President's offer to amend it at a future time.

Mr HASTIE—I have not a question to put, for the deputation have brought back the very answer I expected. As far as my experience goes, the miner is the proper party to put in props. I do not think the table shows the least criterion. For instance, in the Wearmouth district, they do not require to hole the coal. Now, here we require to hole the coal,

and that is where a great many accidents take place. If a comparison were made of the number of men employed and tons of coal taken out, I think it would show a difference in favour of this district.

Mr R. T. MOORE—It is always a difficult thing to reason from statistics. One may try figures from so many standpoints that it is hardly safe to say a system is safer because the table shows it to be so. It must also be remembered that in Durham the mines are flat, and there is therefore less chance of the coal rolling over than if the seams were on a high incline such as at Manchester, Wigan, and some of the other fields. This might account for the fancied superiority of the deputy system.

Mr BEGG—Did the deputation not consider a holing of 5½ feet an extraordinary depth?

Mr DRINNAN—It was not particularly extraordinary to me. I did not know what system obtained about Hamilton, but I had seen the same thing often where I was. However, they were only allowed to do it if the roof was good; if dangerous or weak, they were not allowed to hole any more than 4 feet, so that not too much would be laid bare at a time.

The PRESIDENT—It was only in reply to Mr Hastie's very proper remark that it might be because there was less holing in the Durham districts that there was less risk of accident from falls. In Derbyshire, a great many thousand tons of coal are raised for each life lost by falls.

Mr DRINNAN—I may say with regard to the holing, it is entirely in charge of the overman or underviewer and his deputies to determine from the nature of the roof and floor, how far it should be holed, and any part where the roof is weak they do not allow them to take more than 4 feet.

The PRESIDENT—Why, may I ask, do they require gears at Wearmouth? At sketch figure 2, p. 56, they have crowns and legs.

Mr DRINNAN—I thought I had answered that question of the President's by anticipation and by saying that it is possible they are of the same opinion there as our inspectors here,—viz., that it is as well to put up props and crowns whether they need them or not, because I myself did not see much necessity for having

them there ; and you will observe the cost of timber is very small, showing that the timber must be used over and over again. As soon as the ends are driven through, the whole of the wood is drawn out and not much falls. Of course it is expected a little falls after the place is abandoned, but the fact that the cost of the timber is so small is an evidence that it could not be much crushed in those places, and I did not see any evidence of crushing.

Mr R. T. MOORE—I may say we consider that the system we recommended in our report would be a more systematic method than even the deputy system, because the deputy does not require to put up a prop whether it requires it or not ; if, in his judgment, it could stand, he does not put it up. There is no stated distance with the deputy.

The SECRETARY—From what is said of the wood, I think, with some of the other members, there is really very little use for putting up wood there. They say the props are only 3½ inches diameter, and crowns are 5 inch props cut through the middle. I do not see how they could bear much weight. From what is said a little further down, when the props are drawn from two to three feet generally comes in. In drawing some of the wood in this district, I have seen occasionally a foot come in, but I do not see where these light props could hold up a thickness of two to three feet.

Mr DRINNAN—Mr Gilchrist's question deserves a fuller answer than I am prepared to give to it at the moment. I have no doubt, seeing it is in the report, that we must have been told so, but I have a recollection at the moment in being in one of these places and where the props and gears had been withdrawn and seeing very little fallen. I have no doubt it would be so stated, and before finally leaving the question, I would like to return to it after I have had more time for consideration. Mr Moore has just been telling me, at the time the report was presented to me in draft (Mr Moore drew it out and sent it to the other members) to look over, and I returned it to him with a correction saying this place did not fall. However, he subsequently got information from the manager that it did fall as stated. Of course I was only speaking of it when I was there.

The SECRETARY—Is that not simply putting in trees and taking

them out to get the roof to come down. I have known in some cases where we were anxious to take down part of the roof, we simply put up props allowing them to remain for a week or two, and by then driving them out the roof came down easily.

The PRESIDENT—That has often been done, but the point is, the roof does not come down till you want it.

Mr ANDERSON—The cheapness of the thing strikes me very forcibly here. I think we have a great deal to learn on that point. At the bottom of page 56 the length of the props are given at 8 feet long where roads are timbered. Was there much timber set up on the main roads? The price in the paragraph is 1¼d on the roads and solid places and 2d in the pillar working. It is not my experience to get anything so cheap here, although I heard it said last night in some places they are working cheaper. I should like to know the system that brings about such a very desirable result. Is there anything in the mode of withdrawing the props to account for it?

Mr R. T. MOORE—I do not think any explanation can be given of the cheapness unless the quality of the roof. They were putting up the props just exactly the same as in Scotland. There was a slight difference in detail, but the general system was exactly the same as that in use in Scotland.

The PRESIDENT—Working at the stoops is as safe as anyway else provided you adopt the right principles—putting up a sufficient quantity of wood with the view of carrying the weight, in place of the coal that carried it before.

Mr DRINNAN—I do not know whether I could add anything to the information Mr Anderson already possesses on the question so as to secure greater economy, but my experience in England has shewn me that wood can be drawn out of places that very many of our Scotch miners would consider dangerous. It is done by a "dog" as described in the report, no matter whether broken or not, and what is broken is sent to the mill and cut up for sprags, every Colliery having a saw-mill. The Deputy, as he goes his rounds sees that the miner does not bury any of these props. It is very often attempted, and the miner will heap up the debris until not more than a few inches of the prop can be seen. Still the Deputy has his eye on it, and if the miner has buried it he is

made to pay for it. Before beginning to take out a prop they loosen the top by cutting the roof on the top of the prop and then with the "dog and chain" they are able to pull it out, they themselves being in a safe position.

Mr HASTIE—The cost at Wearmouth will be 3¼d per ton?

Mr R. T. MOORE—The costs are 1¼d in the roads and solid workings and 2d in the pillar workings. They are kept separate.

Mr HASTIE—I think it was I who made the remark Mr Anderson speaks of. I was looking into the matter, and I can tell him there are some Collieries in Hamilton taking out stoops for less than 2d per ton for props.

Mr LOVE—Will the deputation say if the butties' wages were included in the price mentioned here?

Mr R. T. MOORE—No, that is the price for timber alone, not including the deputies' wages.

The PRESIDENT—I should think not, because it does not matter whether the collier or miner does it, it is labour expended in setting the props.

Mr LOVE—There is another point, viz., the position of the round side of the crown: is it better that way?

Mr DRINNAN—I do not think it is better that way, and I asked them for the reason, but neither they nor those at some of the other places where they had it set the reverse way were able to give an intelligent reason. It was put that way because it was most convenient. They themselves seemed to have no idea as to whether it was better set with the round end up or down. They invariably did it in the one way at the same place.

The PRESIDENT—As to the Welsh system of timbering, can you say anything about the peculiar advantages of that system?

Mr R. T. MOORE—The object of this system of timbering was to resist the enormous side pressure that was found in all those Welsh mines.

Mr DRINNAN—I was about to say that I did not start with a very high opinion of the style of timbering and, therefore, was perhaps somewhat inclined to look for faults. I had an idea that the props would be peculiarly liable to be broken in the middle, and I looked pretty narrowly at most of the places to see if there

were any traces of that and I saw a good many. However, I would not like to say it was a universal thing the breakage occurring there, but I have still an idea that wherever there is a heavy top pressure it is likely to give way there. It is very good to resist the side pressure, but where there is top pressure I do not think the advantages of the system are great. Before leaving the subject, I would like to say, lest we should do anything to hurt any one's feelings, that the persons unable to give us a satisfactory reason for the way in which the crowns were put up were not the managers but some of the officials under them.

Mr TORRANCE suggested the tendency in certain circumstances of the sprags to break in the middle.

Mr R. T. MOORE—This notch in the Welsh timbering is done on perfectly accurate scientific principles. The slight notch does not weaken it to any appreciable extent. It is in the middle where it is most likely to break, not at the ends.

The PRESIDENT—Gentlemen who have read the reports will have remarked generally that the wood is heavier than we are in the habit of using.

Mr DRINNAN—In Wales especially it is very heavy.

The PRESIDENT—Perhaps we might turn with advantage to the means of spragging. In looking over the report, I was very much struck with the cocker sprag. It seemed to me to be very good.

Mr RONALDSON—Might I ask if there is any difficulty about the setting of these cocker sprags?

Mr DRINNAN—They find no difficulty at all. It is a thing quite easily done.

Mr R. T. MOORE—At Great Fenton Colliery they put up these cocker sprags before beginning to hole, and then knocked them out after the coal was holed.

The SECRETARY—Could the cocker sprag not be adopted in stooping? In the discussion of Mr Borland's paper, it was stated that the coal in this district was of so friable a nature that it would not stand to be undercut. If by using the cocker sprags this could be done, the percentage of dross would be considerably reduced.

Mr R. T. MOORE—I believe they could, but the difficulty in the

case of the stooping is that you have got so little room. There might not be sufficient room for two or three colliers to get working in a five-yard lift if sprags were put up. It is a different thing in long-wall working with 50 or 60 yards to come and go upon.

Mr ROBSON—The miner does not work the 50 or 60 yards at one time.

Mr R. T. MOORE—One or two cocker sprags are not so much felt in a long face as in a short one.

Mr DRINNAN—Still, I would not like the idea to get abroad that they take up much room. In reality, they do not take up more than a common sprag. It is only the short sprag that goes up from the floor that is really in the way of the collier.

The PRESIDENT—I think it is a very important appliance, and with Mr Gilchrist I think it is very well worth studying whether it could not be applied in many cases here. It takes a while to introduce these things and to make them complete, because, besides shewing the men how to put them up, you have to shew they are necessary and advantageous and useful. If some of our members here were to take the thing up, I believe they would not be disappointed in the result. There are a great many of those schemes which, if worked up, would be useful in several cases. It seems to me that in the Hamilton district, where there is such an immense amount of small coal,—40 or 50 per cent. of dross,—if anything could be done in saving that waste it would be a great matter. I have seen the cocker sprag applied to tender coal with the very best result. Another point is the very great length of holing which prevails in Yorkshire. What is the cause of the holing being so much longer than we are accustomed to here? Was there anything in the circumstances of the working which made it safe to do so?

Mr DRINNAN—I have made some reference to the subject at p. 70. The system of working is shown there, and of course it is an advantage to the collier to have a fall as wide as possible, because he has a road to make along the whole side of his face. He would like to have 5 or 6 or 7 feet if possible, and he has to be restrained by those in charge not to take more than the nature of the roof would stand. They have to work it on end, and the road is made after them. The sprag is taken out and the coal

broken, and if it does not break the collier has to put in a shot. In some of the places we visited, they were taking out three or four sprags at a time. This was simply because the roof was good. At the colliery I was at they were not allowed to take out more than one sprag at a time. There was in that way a great temptation to the collier to hole a great depth so as to get as wide a fall as he possibly could get.

The PRESIDENT—Could this system be adopted advantageously in similar thicknesses of coal here? Was there anything impressed you with the system.

Mr DRINNAN—When you put that question to me, I have to confess I know very little about the Hamilton seams. I do not think that I was ever down one of the pits except one at Blantyre, and I would like to see a colliery before I could say whether or not the system would be applicable. In most seams, I should say, it would not be difficult. I have not made up my mind on this before, but there is not nearly so much brushing with these 60 yard banks as there is with our ordinary 12 yard walls. In opposition to this, for the same area, they have fewer men employed, and in consequence, I have calculated it would take them double the time to win a field of coal than it would take us with our Scotch system, and where you have heavy on-cost charges they form an important item for consideration when determining the best system of winning a field of coal.

The PRESIDENT—It was scarcely with the view of adopting 60 yards places as whether holing to that depth might not be adopted in Scotland. In no seams that I have seen in Scotland is there anything like five feet.

Mr HASTIE—I have never seen five feet. I was a good way through one of these Yorkshire Collieries and I came to some places where I could not get along. That was through a stoppage of the air. I formed an opinion that this was a good system, but I considered the long-wall system of this country better. Then, there are much more troubles in the coal here. They have a very clean field. For miles you will not see a trouble.

Mr ROBSON—A great deal depends on the number of cleavages. I think in Scotland you get backs pretty frequently, but in many places the coal is holed to a depth of four feet in long-wall.

Mr DRINNAN—Generally speaking, the Barnsley seam is a good hard seam. The centre is very hard.

The PRESIDENT—It seems in all the Midland counties that the system of deep holing prevails. When you go to Wales again, the system is very much like our own.

Mr DRINNAN—The withdrawing of the props in the goaf or waste always relieves the face of the weight in some measure. It is certainly an advantage to it.

Mr W. S. RUSSELL—What kind of roof have they?

Mr DRINNAN—A very fair roof. I can only speak of the place where I was for some years and the places we visited, and the roof was very good there. There was only one part of the pit I worked at where the roof was at all tender, and I have seen there the roof and coal all down for a distance of 60 yards and the air still whistling through in sufficient quantity to ventilate the district, though even a mouse could scarcely have made its way along.

Mr AUSTINE—Was there gas?

Mr DRINNAN—Yes, a good deal of gas coming off, but we had a powerful fan which pulled the air through these places. That was an exceptional part of the workings; the roof generally in all that district is more than ordinarily good.

The PRESIDENT—I propose we should now adjourn the discussion till another meeting, and I hope you will all read the report before that time so that we may get the greatest possible information out of it we can. I must say before parting that I am exceedingly well pleased with the way in which it has been got up on the printer's part. I think you will have no difficulty in following up the plans from the descriptions and clear engravings which the printer has given us.

The PRESIDENT having intimated that it was proposed to hold the next meeting at Ayr on the 20th of August, the meeting adjourned.

MINING INSTITUTE OF SCOTLAND.

VISIT TO EARNOCK COLLIERY, HAMILTON,

11TH AUGUST, 1881.

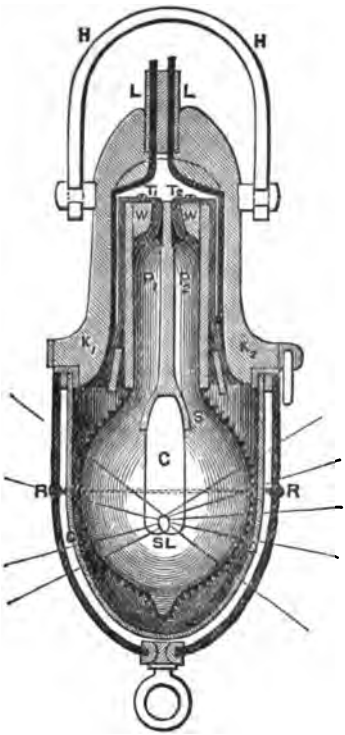
BY the kind invitation of Mr John Watson, upwards of 100 members of the Institute met at Earnock Colliery, on Thursday, 11th August, to inspect Swan's electric light as applied for mining purposes.

In the unavoidable absence of Mr Watson, they were received by Mr James Gilchrist, manager, who conducted them down the pit and through the workings. After a thorough examination of the electric light, and part of the workings below ground, the party returned to the surface and was photographed by Mr Annan, Glasgow. Some time was then spent by the members examining the extensive surface arrangements, after which they met in the Workshops, where the Engine and Dynamo-machine for generating the electricity were at work.

Mr Andrew Jamieson, C.E., Principal of the College of Science and Arts, Glasgow, having been deputed by Mr Swan to represent him at the meeting, was called upon by Mr Gilchrist to give an explanation of Swan's system of Electric Lighting.

Mr JAMIESON said that he had not prepared any speech or lecture for them, but that, as he had been asked some very practical questions by some of the members present during their turn round the Works, he hoped to be able to answer these as well as any others that might be put to him. He believed, and he knew that Mr Swan himself believed, the best plan was not to overrate the lamp, but to plainly and straightforwardly state its

capabilities under ordinary and fairly well managed circumstances. The lamp itself consists of a carbon filament C (see Fig. 1.) of about the size of ordinary sewing thread. This carbon filament is formed by first subjecting cotton crochet thread to the action of diluted sulphuric acid, which causes a conversion to take place in the thread similar in character to that produced by the treatment of bibulous paper with sulphuric acid according to the well-known process of making vegetable parchment. The cotton thread, after being immersed in this solution for a sufficient time, is removed therefrom and washed with water until the whole of the acid is eliminated. It is then dried and carbonised. As shewn in Fig. 1, the carbon filament is formed into a loop, with not unfrequently a double turn. It is made considerably thicker at the ends, which are fixed into steel tube holders at S, similar to an ordinary split steel pen-holder, only smaller in size. These steel carbon holders terminate in thin platinum wires P_1P_2 which project through the end of the glass tube at T_1T^2. The object of using platinum, in preference to any other metal, arises from the fact that the metal platinum comes closest to glass in its co-efficient for expansion by heat. If copper, iron, or silver were used, the probability is, that the greater expansion by heat of these metals than glass, would burst or break the same, or prevent the possibility of retaining a good vacuum. Well, the carbon filament, with its holder and terminal platinum wires is inserted



SWAN'S LAMP, WITH PROTECTING LANTERN.

into a glass tube, terminating in a pear or apple-shaped bulb. The whole of the air contained in this glass tube and bulb is carefully removed by means of a Sprengel air pump, and the bulb hermetically sealed by a blow-pipe at the lower nipple. The carbon, therefore, remains in as perfect a vacuum as practicable. Over the end of the glass tube Mr Swan places a very neat papier-maché ferule, with two gilded side contact pieces. L L, branch wires;—the branch wires are brought in at the top of the casing, and down till they come in contact with the side contact pieces of the lamp ;—(K_1K_2), top part of the lantern, made of wood ; H H, handle for carrying or hanging up lantern ; G G, bottom part of lantern, strong glass ; R R, wire rods for protecting glass. This ferule has a wood en plug inserted into its upper end, to which by means of a couple of small screws, the side contacts (K_1K_2) are securely fixed to the platinum wires at T_1T_2. As seen in the figure, the Swan's lamp is shewn inserted inside a protecting lantern similar to those you saw at the front faces. It can, however, with equal readiness, be inserted in lanterns of ordinary shape, like street gas lanterns, the whole object of a lantern being to prevent as far as possible the more tiny Swan's lamp from getting broken, and by means of suitable reflectors to distribute the light or concentrate it as desired.

The electric current generated by the engine revolving the inner coil of the A Gramme Machine, passes from the positive pole thereof along one of the conducting wires down the shaft and crosses to the other or return wire by the various Swan lamps which are joined between the main wires by branch leads. In doing so, it meets with resistance in the firm carbon filament, and in overcoming this resistance the electric current displays itself by generating its equivalent in heat, and thus rendering the carbon incandescent. The great object is to keep the resistance of all other parts of the electric current, such as the Gramme coil, the leading wires, both large and small, and the platinum wires of the lamps as small as possible compared to the resistance of the carbon filament, so that a maximum amount of the energy generated by the engine may be concentrated in heat or light-giving marks at these points. The beauty of design of the Swan lamp and the ingenuity displayed are very great, and all will, no doubt,

recognise in it a useful means by which their dark coal galleries might profitably and advantageously be lighted. Of course, difficulties would be met with at first, and many improvements must follow before it could be considered perfect, but even in its present condition he would have no fear in guaranteeing a much better and steadier as well as safer light than could be produced by means of gas.

Mr Jamieson, in the course of his exposition, further explained that there was a great liability of the lamps to break in so far as they were extremely tender and fragile. This was a great drawback. Through time the carbon filament burned away. He did not think the Swan lamp would last more than 400 hours—the minimum would be 300 hours. There was no use of their running away with the idea that it was to be a permanent thing, and that they would not need to replace it. He thought, as he had already indicated, that it was the greatest mistake to give the lamps too good a character. They cost 25s each when new, and 5s for each renewal. It was very evident Mr Swan must come down in his prices, because there were opponents in the field. Referring to the means adopted for generating the electricity, Mr Jamieson mentioned that if their engine were going irregularly, there was another means which might be made available—viz., the new Faure battery, which possessed the capability of storing electricity, and which was ready at hand at any moment. With it they did not need to lay down a special engine. One going irregularly to charge the Faure battery was alone necessary. They had only, then, to take it from the machine to the mine, and it did its work with about 75 per cent. of efficiency—Sir William Thomson said more. In ordinary cases, the engine driving the dynamo machine had to go with very great regularity as regards speed, or, otherwise, they might see the pulsations in the lamp itself, whereas by the adoption of the Faure battery they could have a perfectly steady light, and could use it at any moment whether their engine was going or not. Mr Jamieson stated further that, with a few necessary precautions, there was no reason why an ordinary mechanic should not be able to look after the whole matter and give no trouble.

Mr DRINNAN—I wish to ask a question—although I am not quite sure if the Principal is the proper party to put it to—in connection with the lighting up down below. So far as I observed there were none of the colliers using the light at the working faces. Now, I was struck with that fact, for, considering the time they have been experimenting, I thought, if practicable for the miners to work with it, we would have seen them working with it to-day, and I wish to know if there was any reason for their not doing so?

Mr JAMIESON—That is a question for you, Mr Graham, to answer.

Mr GRAHAM—Our men were extending the wires at the far away face and, for want of time, had not been able to regulate the current.

Mr SHARP—Suppose a lamp were broken at the face, in the presence of inflammable gas, would it explode the gas?

Mr JAMIESON—I am certain it would, if the glass shell were broken. I have been talking a great deal with a leading chemical analyst, and we are quite sure that it would take an appreciable time before the carbon filament would cool. Now, less than one-tenth of a second, or say an almost inappreciable time, is capable of exploding explosive gas. I do not see there is any safety in the Swan lamp by itself if placed at the front in a fiery mine and left to its own chance; but with a good lantern, or protecting case, one-sixth of an inch thick, there is a minimum chance of its getting broken. Of course, no explosive gas can get at the Swan lamp as it at present stands, and there is no chance so long as it is not broken of causing an explosion. The experiment of trying to break a *bare* Swan's lamp in an explosive atmosphere is the most severe test possible.

Mr SHARP—But the lamp could be opened?

Mr JAMIESON—Oh, certainly.

Mr SHARP—In the mine, I saw a gentleman open one of the lamps, and, whilst he was shutting it, the sparks were flying from it very rapidly. That would cause an explosion?

Mr JAMIESON—Most decidedly; but you could make it with a key, which nobody could open except the fireman or manager of the mine.

Mr GILCHRIST here explained that he had made provision for testing whether Swan's lamp would explode gas if it was broken in a mixture of inflammable gas. Mr Gilchrist then introduced Mr A. R. Bennett, member of the Society of Telegraph Engineers and of Electricians, Messrs D. and G. Graham's Chief Engineer, who, he said, would explain the fitting up of the light.

Mr BENNETT—Mr Jamieson has very fully, I think, explained the theory of the Swan light ; but he has not entered into any details as to the fitting up of the lamp in this particular mine. I may inform you, therefore, that it is carried from this workshop to the pit-head, a distance of about 250 yards, by a bare copper cable, three-eights of an inch in diameter, on ordinary telegraph poles, the cable being insulated at each support. At the pit-head the conductor is changed to one consisting of 19 copper wires, No. 22, B.W.G., which is effectually insulated by a thick coating of gutta-percha covered with tarred tape. It is taken down the shaft in a galvanized iron tube, and from the pit-bottom extends into the ramifications of the mine, supported upon wooden uprights, for 300 yards, then it is laid along the pavement to the faces,—in the latter case they are covered carefully to protect them. By the side of the main conductor and co-extensive with, and, in every respect similar to it, is carried the return wire ; and between the two are looped the branches of smaller insulated wire, in which are interposed the lamps, switches, and regulators. The course of the current originating in the dynamo-machine is consequently through the main conductor to the pit-bottom, where it divides equally between the various branches, in each of which is placed a lamp, and thence through the return wire to the dynamo. The light is produced in the lamp by the high resistance offered to the passage of the electricity by the carbon filament which, by reason of its small area and the inferior specific conductivity of carbon as compared with copper, exceeds many times that of the connecting wires. The friction set up by the electricity in forcing its way through such a confined passage shows itself in the form of heat and light, which are both proportional to the quantity of current passing. In technical language, each lamp requires one weber of electricity to raise it to the necessary degree of incandescence. The switches, one of

which is attached to each lamp for the purpose of lighting or extinguishing it as may be required, are of novel and peculiar construction, having been designed specially to prevent any possibility of a spark being communicated to the atmosphere of the mine. A spark is always caused when a current strong enough to render one of these lamps incandescent, is closed, or broken; and if such a spark were not prevented from reaching the air it might, in the case of a fiery mine, occasion an explosion. By a simple device, however, such an accident is rendered impossible. A globule of mercury is enclosed in an air-tight tube, pivotted at the centre, into one end of which the two extremities of the lamp circuit is brought. By tilting the tube to the right, the mercury descends by gravitation, joins the two wires and allows the current to pass; by tilting it to the left it leaves them free and interrupts the current. Various other forms of safety contact-makers have been designed and tried, but this is the one we find to answer best. It has been observed, I believe, that the miners were not working to-day by the aid of the electric light. Well, there were two faces fitted up, at one of which I know from personal observation that the light was brilliant enough for the men to work by, and if they had lamps in their bonnets it was an unnecessary precaution. With regard to the other face, the far-away one, I was not there, but as our men only started to illuminate it a few minutes in advance of the visitors, the arrangements cannot be said to have been as complete as they would have been had more time been available. I am informed that the light at that far-away working was very dim—why, I have not yet had an opportunity of ascertaining—but there is, nevertheless, no doubt that we shall be able to exhibit it there as strongly and as brilliantly as at the pit-bottom. It is simply a matter of arrangement. By equalizing the resistance of the different branches, means of doing which have been provided, the light must be the same in all. By increasing the resistance of those near at hand we shall be able, if necessary, to force more of the current through the distant ones. Mr Jamieson has referred to the Faure Secondary Battery as being likely to shortly supersede lighting by direct current from Dynamo Machines. I think that there can be no doubt—indeed, it is an accepted fact

—that the Faure Battery will in the future play an important part in electric lighting; but the present construction of the cells, which are bulky and composed almost entirely of lead, causes them to be very heavy and difficult to transport. As a considerable number of cells are required to equal one dynamo, the battery in its present form would be but a clumsy contrivance for a coal-mine. In fact it would require hutches, such as you use for the coal, to carry it from place to place; so, I think, until it has been improved, as it will be, a dynamo machine is preferable to a secondary battery. A battery composed of a large number of cells might, however, be stationed near the bottom of the shaft and charged periodically from a dynamo machine here, the charging wires being subsequently replaced by those communicating with the lamps in the mine, which would by that means be illuminated until the electricity stored up in the secondary battery by the dynamo had become expended.

Mr HASTIE—How much illuminating power do you consider there was in the lamp at the face?

Mr BENNETT—About 15 candles.

Mr HASTIE—What strength of an engine would you require for 300 lights?

Mr BENNETT—Very considerably more than at present, but it may be readily calculated. I may mention that there are machines now in the market which are capable of doing more work in proportion to the power consumed than the one we have here, which is of the type known as the A Gramme, and is rather antiquated, although a very good one for ordinary purposes. Mr Gilchrist suggests that I should say that it is possible to so regulate the strength of the current in the main circuit that its power may not become too much for the lamps, which, as they are rather costly, is a very desirable object to attain. It can be done by introducing into the main conductor a coil of wire through more or less of which the current can be shunted at will. We have such an apparatus here, which, although it, in its present form, is useless for practical purposes, will do very well to demonstrate that the intensity of the current is variable at pleasure. When the experiment with explosive gas is carried out, I shall be happy to show its working.

The SECRETARY—With regard to Mr Bennett's statement about regulating the current, it can be done, but at a considerable loss of power or light, and so far as the experiment has gone the light is not as good as was expected.

Mr DRINNAN—I was going to make a remark with regard to that. It might be I was somewhat unfortunate in the time I got to the face ; but certainly then the lamps had not the illuminating power that Mr Bennett alleges. Was that due to an error in detail and not to the great distance from the generating machine ?

Mr BENNETT—I think the lamps at the first face gave the requisite light, but am told that those at the second were very dim. As before stated, these lamps were fitted up in a hurry for the inspection of the visitors, and there was no time to remedy any defects. The cause of the dimness has yet to be ascertained, and I have already said that whatever it may be, it can be easily obviated in the future. We can regulate the resistance of the nearer branches and so increase the supply of current to those far away. This machine is one of the smallest of its kind, and is scarcely equal to keeping 22 lamps going at such a distance. If they were in this room it would light them in the most brilliant fashion, but the current has to traverse a mile and a half at least of conducting wires, by which its energy is much diminished. By having a larger dynamo we can effectually overcome all these difficulties.

Mr WADDELL—When I was in at the first working-place the light was certainly not what it should be.

Mr BENNETT—I was there only once and it was very good at that time.

Mr MUIR—There was an interruption to the whole current in the mine ; immediately afterwards the light was steadily glowing, so that may have been the reason for the lights being more brilliant at one time than the other.

Mr BENNETT—Our men were working with the wires at the far end of the mine, and by accidentally making a short circuit they momentarily diverted the whole of the current through the long leads. Then, when we first started, the engineman went at a very low speed, as we think it well, in case all the lamps are

not in circuit, to start slowly and get up speed afterwards. Latterly, I think the lamps were as brilliant as could reasonably be desired.*

A MEMBER asked a question as to the cost of fitting up the light.

Mr BENNETT—No doubt Messrs D. & G. Graham will supply this information on application. As Mr Jamieson told you, the primary cost of each lamp is 25s ; but Mr Swan undertakes to replace every broken one at 5s. That gives an idea as to the price of the lamps, but the cost of fitting up depends very much upon locality and circumstances.

At this stage the experiment was tried to test the point as to whether gas would be ignited by the lamps, if by any accident the glass was broken, in a mixture of inflammable gas. For this purpose a box 15 inches square and 2 feet deep was suspended from the roof, enclosing a Swan lamp, and containing a pane of glass on one side, through which the lamp was seen burning. The box was filled with coal gas until it reached an explosive point, which was ascertained by the insertion into the box of a Davy lamp. The crucial step in the experiment was then taken —the glass globe within which the incandescence is carried on *in vacuo* being broken, when immediately the gas inside the box was ignited and exploded. This was taken as conclusive, as Principal Jamieson had previously admitted on the point as to the Swan lamp only being safe so long as it remains intact.

On the motion of Mr J. T. Robson, a vote of thanks was accorded to Messrs Jamieson and Bennett for their addresses;

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*NOTE.—The cause of the dimness of the two lamps at the inside working was subsequently found to lie in the lamps themselves, which, like many of those lately supplied by Mr Swan, were of very high internal resistance, requiring much more current than the older ones to raise them to the same degree of incandescence. Had this fact been known it could have been provided against, but unfortunately it was not. As I stated to the members of the Mining Institute, the lamps were only fitted to the wires a few minutes in advance of the visitors, and no steps could be taken before their departure to substitute other lamps or furnish more current. Had one of the lamps which were shining so brightly at the pit-bottom been transferred to the inside face, it would have given as much light there. This was actually proved the following day.

A. R. BENNETT.

and on the motion of Mr J. M. Ronaldson, a similar compliment was cordially given to Mr Watson of Earnock (coupled with Mr Gilchrist, manager), for his great kindness in inviting the members of the Institute to inspect the new light.

Mr GILCHRIST, on behalf of Mr Watson, begged to return thanks. He was sure Mr Watson would be pleased to hear that so many gentlemen had come to examine the new light. Mr Watson expected to have had the pleasure of meeting them personally, but pressing business had called him away.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 20th AUGUST, 1881,

HELD IN THE

KING'S ARMS HOTEL, AYR.

RALPH MOORE, Esq., President, in the Chair.

THE PRESIDENT.—I think your Council act very wisely in once a year at least changing the place of meeting, because I have before me a number of faces which do not come to our meetings at Hamilton. It is evident the more numerous the attendance, the more light will be thrown on the subjects; and it is very much to be desired that the papers we have should be thoroughly discussed, because it is only by such discussions that the papers are made valuable, and the writers of them, as well as ourselves, receive much help. I do not intend to say anything more, because our time is going ahead. I am much pleased to see so many here.

The Secretary then read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were admitted as Ordinary Members:

JAMES RUSSELL, Managing Director, Cambuslang Coal Co., Cambuslang.
N. C. HUNTER, Cashier, Omoa Iron and Coal Co. (Limited), Cleland.
ARCHIBALD GILCHRIST, Manager, Polton Collieries, Bonnyrigg, near Edinburgh.
JOHN BEVERIDGE, Manager, Kelty Colliery, Blairadam.
JOHN DUNCAN, Manager, Leven Colliery, Leven.
WILLIAM TURNER, Manager, Chapel Colliery, Newmains.
ARCHIBALD MILLAR, Wood Merchant, Motherwell.

Other forty gentlemen were then nominated as Ordinary Members, and will be balloted for at the first meeting.

The PRESIDENT, referring to the visit of the members

to Earnock Colliery to inspect the Electric Light, said he hoped some of the members by and by would give them their ideas on the subject, but it was not considered necessary, in view of their other business, to open a discussion on it just now. He observed that the number of gentlemen proposed as members to-day was the largest they had ever had at a single meeting. He was very glad to see the numbers increasing. He always told them if the Institute failed it would not be for want of funds but of papers, and he wished to impress that upon them. They had hitherto had a considerable number of papers, but the other members must come forward. Their membership was now nearly 400. (Applause.)

ON A NEW HYDRAULIC PUMPING ENGINE,

By Mr DAVID JOHNSTONE, 12 York Street, Glasgow.

It is unnecessary for me to describe to a practical audience the difficulties experienced in raising water from the lower workings of a mine, so as to bring it under the control of the main pumps in the shaft. I think we will agree that whether the power be conveyed by steam direct, by wire ropes, by rods, or water-power, all are objectionable, but since in many cases such pumping must be done, the best that we can do is to find the least objectionable means under the circumstances, and adopt it. I think it would not be far wrong to state that steam is the most objectionable, more especially for long distances, firstly, because of the amount of power lost in condensation; secondly, from the evil effects of leaky joints and exhaust steam, though the latter may be got rid of by condensing, but the former cannot altogether be avoided where there are much expansion and contraction; thirdly, on account of the heating of the air in the roadway where the steam pipes are laid, more especially if it is used for traffic. As to wire rope systems, whether on the endless principle or used for a pull only, they require a deal of attention, and are very expensive to keep up, the more so if there are many curves. The conveyance

of power by water has many advantages over the other modes—Firstly, there is no loss of heat as with steam ; secondly, the joints once properly made there is no tendency to leakage through variation of temperature ; thirdly, there are no evil effects from changes of temperature, as it is always about the same as the surrounding air ; fourthly, there is no wear and tear in the pipes, hence not the loss of power and material by friction as in ropes and roads ; fifthly, neither attention nor lubrication is required as in the other systems, hence a considerable saving is effected. The Hydraulic Engines shown in the drawing before you are quite portable, and require no foundation or fixing, which makes them very handy for driving dooks. They can be had in sizes to be attached to an ordinary hand-pump, or as combined engines and pumps, to raise 10,000 gallons per hour. Above that size, for various reasons, it is preferable to put in two or more pumps. The respective diameters of cylinder and pump-barrel are proportioned to the difference of level between the supply and discharge, and suction and discharge. The fall of a dook from the discharge to the engine is not taken into account, as the exhaust water from the engine enters the delivery pipe above the valve chest, so the power gained by the fall of dook is just balanced by the back-pressure on the piston, but of course an allowance must be made for friction, which varies with the length and diameter of the pipe as shall be seen shortly. The supply-water may be had from a pond on the surface, from a lodgement in the shaft or upper seams, or by tapping the rising column, and should never be less than ten fathoms above the discharge—if nearer a hundred fathoms so much the better. In every case where water is run from an upper lift to keep the bottom one from drawing air, or where any growth of water having a fall of more than ten fathoms to the sump can be collected in pipes, these engines can be worked, and the water pumped for nothing. Where these conditions cannot be had, and where the main pumping engine is already over-burdened, the hydraulic system cannot be applied. The best speed of piston or pump-bucket is about 24 feet per minute, or within a range of from 18 to 30 feet. At a speed of bucket of 24 feet per minute, the area of the bucket in square inches is equal to the

number of gallons raised per minute. For example—say it is one square inch, we have 24 by 12 (the speed of the piston in inches) equal 288 cubic inches displaced. The number of cubic inches in a gallon being 277·2; this leaves a margin of 10·8. It is a near approximation, and saves a deal of figuring. The diameter of feed, and, especially, discharge pipes should be large, as the loss of head in forcing water through long pipes is inversely as the fifth power of their diameter. For instance, take a two-inch and a four-inch pipe of the same length, in order to force the same quantity of water through them, the difference of loss of head would be as 1024 is to 32; or say, 60 gallons per minute had to be discharged at a distance of four hundred yards, the two-inch pipe would require 185 feet of head, while the four-inch pipe would deliver it with a little under six feet of head. The following table, taken from Molesworth, is calculated for five feet of head to force the quantities named through a thousand feet of pipe of the diameter given opposite :—

Diameter of Pipe.	Supply in Gall. per Min.	Diameter of Pipe.	Supply in Gall. per Min.
2 Inches.	12	8 Inches.	400
2½ „	20	9 „	530
3 „	30	10 „	700
4 „	60	11 „	900
5 „	100	12 „	1,000
6 „	180	15 „	2,000
7 „	270	18 „	3,000

Odd numbers are omitted, but this will be found near enough for practice. For numbers between, if there be head to spare, the smaller size may be taken, but if the head be short it would be advisable to take the larger size. A reference to the drawing (Plate XX.) will explain the construction of these engines. Fig. 1 shows a section through the cylinder, and pump barrel. (A) is the working cylinder proportioned to the head of water and the work required; (B) is the piston which is composed of two discs fixed to the piston rod, enclosing two packing rings of lignum vitae, each ring cut into three segments, and kept tight to the cylinder by a metallic spring ring.* The piston road (K)

* Pump bucket (J) on this drawing is formed in the manner described, but the piston is shown as two metallic cups, which, when the water is very clean, make very good hydraulic pistons. They have to be thinned away to a fine knife edge, and when properly made will expand with the pressure like an ordinary cup bather.

continued into the pump and has the bucket (J) fixed on its other end. The stuffing box through which it passes is enclosed in the casing (C) which forms part of the pump chamber. It is the only stuffing box on the engine, and can be adjusted through a smaller door in the casing. (A^1) is a small cylinder for reversing the valves of the large one, and the piston rod is fixed to the cross-head (E) which works on a guide at one end, its other end being rigidly fixed to the valve spindle (D) of the large engine. Fig. 2 shows a section of the valve chambers with the piston valves. The pistons are formed by alternate rings of brass and leather. The portion of the cylinder in which they work is lined with gun metal, the chamber being continued into the cover. The ports are formed by a recess in the cover round the valve chambers and continued over the cylinder. The valves are so adjusted that when the valve at one end is in the portion of the chamber formed in the cylinder the other is in the chamber formed in the cover, leaving a free passage through the port for the feed, while at the other end a free passage has been left through the cover for the exhaust which is collected in the casings at either end, and escapes by the pipe (C), to which a branch can be attached to lead it into the delivery pipe. Fig. 3 shows a section of metal through cylinder, and Fig 4 plan of valve gear in casing. The *modus operandi* is as follows :—When the main piston is nearing the end of its stroke on either side, it strikes a tappit, which, acting on the beam lever (E^1), shifts the valve of the small engine which, through the connections already explained, reverses the valve of the main engine just as the stroke is being completed. The engine being once started, this series of operations will go on as long as the pressure is maintained. The mechanism is all contained in the casing (C), and is surrounded with water, which acts as a lubricant, and by removing the door it can be examined at once. All the working parts are of brass, working in brass liners. The bearings are all made to obviate the use of stuffing-boxes. All the working parts are round, so that they can be finished in the lathe, and they are simple and easily renewed. The small engines for attaching to hand pumps are similar to that already described, with the exception that there is only one tappit

which is pushed outwards when the main piston approaches it, and drawn in when it recedes by a wire with a button on the end. A combined engine and pump, constructed to raise 25 gallons of water per minute from a dook of 200 fathoms long with an inclination of 1 in 12, has been working very satisfactorily for several months at the Monkland Iron and Coal Company's Spindleside Colliery, and an engine, same as described, but attached to a hand-pump, has been at work at one of the pits of the Flemington Coal Co. (Ld.), Cambuslang, for the last eight months, and is doing its work well.

In reply to the President, Mr JOHNSTONE stated that in his calculations he allowed for 70 per cent. of loss. He got 85 per cent. out of the engine, but only allowed for getting 30 per cent.

The PRESIDENT.—Putting it in another form. Suppose you had a steam engine of 100 h.p. on the surface and, instead of having pumping rods you put a water engine at the bottom of the pit, you would have 70 horse power given off by this water engine?

Mr JOHNSTONE—80 to 85 per cent., but I would not guarantee this.

The PRESIDENT—Supposing you were to employ a very economical steam engine at the surface to raise the water pressure, you mean that you could work a water engine at the bottom of the pit instead of having pump-rods and other paraphernalia, and you could do it more effectively and economically?

Mr JOHNSTONE—No. It was for dook pumping, but I can see the force of it. At Spindleside, we got 40, very closely on 50 feet of piston speed, and calculating for the diameter of pipes and length we had 70 per cent. of power. I allow a third for friction, a third to do the work, and a third for casualties. The engine power is the double what it is given out for, but it is best, I think, not to give them out for more than a third of their theoretical duty, leaving the rest for friction. The most important thing is the pipes, because I was astonished myself to see what the theoretical value of pipes was—that the increase is the fifth power; it is 32 to a 1024 in a 2 in. and 4 in. pipe. I am taking it from the best tables on hydraulics. The experiment is to fill a tank and see how long it takes for that water to run through with different sized pipes.

The PRESIDENT—Our usual custom, as you are aware, is to continue the discussion until the paper is printed; but Mr Johnstone has referred to some parties who are using his pump. First, Mr Wingate, who will be able to say something about it, and we have also Mr Jamieson, who will give us his experience of it at Spindlseide.

Mr WINGATE—I will bring up a full statement at next meeting. All I can say at present is just this, that our hydraulic engine is simply an organ blower, where the organ is a pump to which we applied it. It is placed at the foot of a dook about 150 fathoms or thereby. The pump used to be wrought by a man, but Mr Johnstone's engine has done the work satisfactorily, and as to economy, we find we do not require any more above ground pumping, and it is saving a man's labour continually.

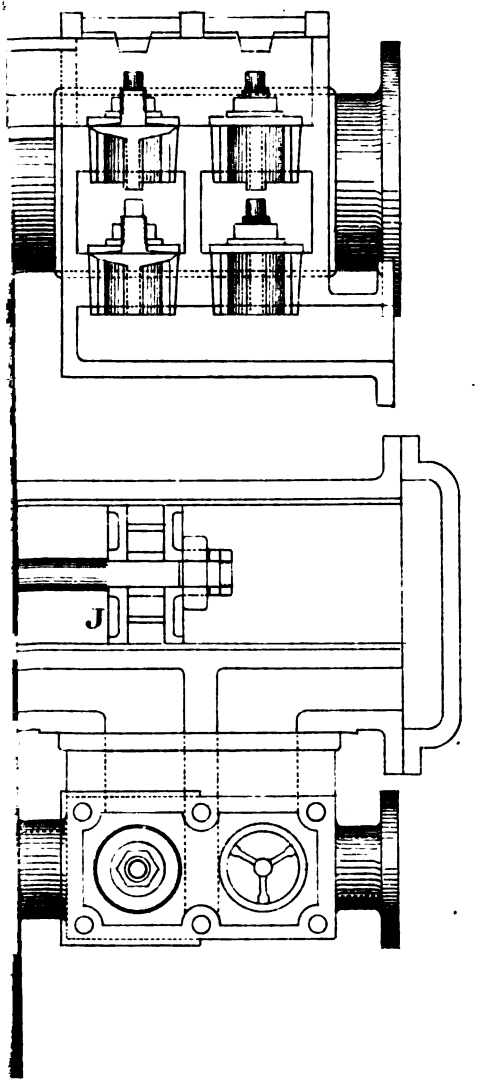
Mr JAMIESON—Our pump, which commenced work on the 4th June, is one of the large size. We take the water power from the surface. The depth of the shaft is 40 fathoms; from shaft to top of dook is 80 fathoms level; from top of dook to where the pump is lifting water from is 100 fathoms. There is a rise of 23 feet on the distance or 1 foot in 26 feet. We have had no trouble with it, as it has wrought well and given every satisfaction.

The PRESIDENT—The pump is simply two engines, one working another. There have been many of these kinds of pumps tried. I must say this looks very simple, and I dare say in many cases might be applied satisfactorily. I forgot to ask the size and the weight of the pump?

Mr WINGATE—Ours is a thing weighing, I think, about 56 lbs. A man takes it in his "oxter."

Mr JAMIESON—Ours is 10 cwt., but it is easily enough shifted. The size of the cylinder is 6½ in. and the bucket is 5½ in.

The PRESIDENT—The great difficulty with hydraulic engines is this: whether you are working 10 ft. or 40 ft. you use the same amount of water. That is the difficulty with the whole of them unless one made by Mr Hastie of Greenock, wherein he contrives a certain arrangement by which the stroke of the piston is altered. When the power required is great, the engine works its full stroke; when it is less, by an automatic motion, it is a short stroke. There is a considerable amount of machinery about it. I am not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putting it up as against Mr Johnstone's pump, but merely wish to show that these machines are very applicable, although not at all times so economical as might be desired.

Mr ROXBURGH asked if Mr Johnston had adopted any means whereby the piston knocking at the end could be prevented. He mentioned in the case of a hydraulic engine working at Devon Colliery that this was the only point he considered unsatisfactory.

Mr JOHNSTONE—In my machine there is no knocking, I think, whatever. The cylinder is large, when there is knocking. The only remedy is to line the cylinder or tighten your valves and give it more friction. The reason why it knocks is the main piston has more work than the small one, and the water goes to the one instead of the other; and if you cushion the small piston there will be no knocking. In reply to the President, I have taken into consideration what he talks of, viz., the waste of water, I do that by lining. I have a simple method of lining—by putting on brass lining, with fitting strips.

The PRESIDENT referred to the results obtained by Sir William Armstrong by the introduction into his machine of an injector. He expressed himself pleased with the size of Mr Johnstone's machine. Mr Jamieson's seemed rather heavy, but Mr Wingate's must be of very great service. He also noticed a piston arrangement by which Sir William Armstrong takes up the recoil of the great guns which he supplied to the Italian Government. Probably there was one pressure better than another; if they could go as high as 500 or 1000 lbs. to the square inch without affecting their valves, the highest pressure would be most desirable, because they would have the engine in less bulk.

Mr JOHNSTONE—I would lengthen the bearings—give them very long bearings. The machine was not at first invented for an engine, but for a water meter. He could work it with 8 inches of a head of water.

The PRESIDENT—The greatest pressure has been what?

Mr JOHNSTONE—That at Spindleside.

The further discussion of Mr Johnstone's paper was then adjourned.

SAFETY LAMPS.

The PRESIDENT—The Committee on the German Safety Lamp which you had before you sometime ago are desirous of increasing their number and still carrying on their experiments. They do not feel disposed at this time to make any report, but wish you to sanction the addition of the following gentlemen to the committee:—Mr Austine, Mr Grant (Bothwell Castle), Mr Hamilton Smith, Mr Beith, Mr Wingate, Mr Robson, Mr Ronaldson, with power to add to their number. They propose to investigate the whole subject of Safety Lamps.

The proposal was unanimously sanctioned.

THE REPORT AS TO METHODS OF SUPPORTING THE ROOF AND SIDES.

The PRESIDENT invited the members to continue the discussion of the report of the deputation on methods of supporting the roof and sides.

Mr ALEXANDER—I was struck with the recommendations of the deputation, who, after examining so many places of which they have given a very clear and satisfactory account—an account thoroughly intelligible to any one—in that they did not report in favour of the Newcastle system, about which we have heard a great deal. Moreover, if we take the return which they give, apparently the result is superior there to anywhere else, but the deputation do not advise it. I would like if some member of the committee would just give us one or two reason why they do not.

Mr R. T. MOORE—Although the tables at the end of our report show such results about accidents from falls of roof in Durham, we came to the conclusion which we have given in the report after carefully considering the whole of the systems. We thought that the system which we recommend was preferable to the deputy system, because, although the deputy puts up all the

props, it is left to his judgment at what distance he should put them apart; and after all it is a matter of the judgment of the deputy instead of simply of the judgment of the collier; but if the system we recommend is adopted it would not be so much the judgment of the individual deputy, it would be that of the manager as well, and the collier would have to put the props up at least at the distances stated by him. This makes it more systematic than the deputy system, and there is still the deputy going about to see that the props are put up and the system carried out. The smaller loss of life in Newcastle aud Durham might be owing to many other causes than the operation of the deputy system. It is scarcely fair to say "Durham has a small proportion of fatalities; the deputy system is in use there; therefore *it* is the safest." It is a bad argument. The conclusion may be true or it may not, but it does not follow from the premises.

Mr ALEXANDER—I am very glad to have Mr Moore's explanation, it agrees very much with my own ideas. It depends altogether, I think, on the roof, at least in a great measure on the roof when wood is put up or required, but whatever the mode is let it be systematic. If it is a good roof, and you require only one support for 6 feet, let it be done regularly; if for every 3 feet let it be done in the same way and not leave it altogether to the workman to decide when it is or is not necessary to put up a support. We all know what that means, because if a man is very anxious to get his hutch sent away full, or his drawer is very urgent, he sometimes forgets to put up wood at the right time. Unquestionably systematic putting up of the propping is the right way. There is more in *that* than in any particular system. Then, again as to comparisons, Mr Moore is quite correct in saying there is much to be taken into account. Why, there is one pit I could refer to where, at the present day, there are 82 miles of passages standing, and I do not think in forming those passages one man was lost by a fall of roof. Now, that is altogether an exception and the effect of a good roof, and to compare a district with others, if that particular district has what you would term a good roof—why, it is no comparison at all. (Applause.) I do not know if those gentlemen who visited these various districts would be

able to say whether it is an exceptional roof in the Durham district. However, I think the principal point is, whatever the mode of support given to a roof, let it be done in a systematic way, and at the least see that it if is not made a general rule, that it is made a special rule. If the management decide that at 5 feet a support is required, let that be the special rule. I do not think we could make a general rule generally applicable, because there are no two collieries alike, but a special rule might be framed applicable to each seam and in each colliery.

Mr RONALDSON—One thing has struck me in looking over this report, and that is the temporary use of propping, which seems to be in favour in a great number of collieries visited. There is a great deal more made of this temporary propping in England than in Scotland. Seldom in Scotland do we think of drawing props or chocks in long-wall workings. Here are examples of props and chocks taken out systematically and used over and over again even in long-wall. Perhaps some of the practical members would say why we do not follow out this system so much, or state what is to be said in favour of leaving in all or most of the props as we do at present.

The PRESIDENT—These are very pertinent questions, and there are none more able to answer them than yourselves. I think we should have had some remarks about the means of supporting the sides. You will observe in the report how systematically they appear to put in sprags and props. I think it is very deserving of your notice that part of the report relating to the mode of supporting the sides as well as the roof, because as you know there are many accidents from that cause. There is more in it than that, because it is evident supporting the coal will do good by enabling it to be worked to more advantage. Then the holing in some places was found to be to the extraordinary depth of 5½ feet. We never attempt anything of that kind here, and I presume they could not do it there but by the means of supporting the coal by sprags and cocker sprags. Is there anything not quite clear on that subject?

Mr DIXON—In the first place, I have to congratulate the committee on this very excellent report. I think it is equal to that on rope haulage of the North of England Institute, which is

saying a good deal. The subject, just referred to, viz., deep holing and supporting the faces with sprags, I suspect have a good deal to do with the length of the walls in England, and it comes to be a question whether we could not advantageously lengthen the walls. I looked into the report in connection with this matter and selected the following collieries in which there are long faces, viz.:—Florence Colliery, faces 88 yards long; output from each 40 tons per day, equal to 9 cwt. per yard. High Park Colliery, faces 50 yards long; 48 faces or 2400 yards per 900 tons a day, equal to 1½ cwt per yard. Kirkton Park Colliery, faces 60 yards long; output 25 tons each, equal to 8 cwt. per yard. In Scotland with a coal 5 feet to 5½ feet high, a couple of men will put out at least 8 tons per day from a 12 yards face, equal to 13⅓ cwts. per yard, and with machines cutting a yard deep per day in such a seam, the output would be at the rate of 30 cwt. per yard. Few fields if any in Scotland are so situated as to be able to develop a face a mile or a mile-and-a-half in length, so that the advantages of getting a larger output from a smaller area, and thus curtailing the expense of upkeep of roads, haulage, &c.,and giving facilities for both ventilation and management, may compensate for the extra outlay in brushing.

Mr ALEXANDER—Perhaps you would inform us, Mr Moore, if by the deep holing there is any less dross produced than by the present system?

Mr R. T. MOORE—The deep holing was not so much due to saving in the coal as to the fact that the rails were laid in the space where the coal was dropped. If the collier could have got in with his road with 3 feet of holing, he would have done so.

Mr ALEXANDER—At a colliery near to where we are sitting, when I first knew it, the holing was done on the top of the seam. They made a good average holing, and, afterwards with pinches inserted in the "end" rents, brought down the coal. Now, at the same colliery they are holing at the bottom. Such changes require to be made to meet the altered circumstances of the seam and its surroundings a good deal.

Mr JAMES A. CLARKE—In regard to the colliery referred to by Mr Alexander, I think the reason is that the clay they used to hole in is very much thicker. It used to be 10 inches thick, and

it is as much as 3½ feet now. That is one reason; another is they take both seams together, and work stoop-and-room, while it was long-wall then. There is a good "daugh" underneath, which is a further reason for the change.

Mr BRYDEN—In looking over the report, I was struck with the length of walls and the number of chocks used in them. The chocks must be very expensive. Is there no danger of a grand crush taking place and losing them? As to the breaking of the roof, breaking across wood is not so effectual as breaking across the coal in taking stoops out.

Mr R. T. MOORE—At the Pendleton Colliery, where those chocks were used, two lines were kept in, and when a third was added the first line was drawn out. The chocks were expensive at first, but they were used over and over again, so the expense was not so much per ton. The roof did not seem to crush the chocks in any way. It took very little time to put them up; they had one fireman who put them up for 30 men and a contractor to take them out, and altogether they were not costly. They broke the roof as well as it would have been broken over the coal, and they had the advantage of allowing the face to be advancing constantly, and not in lifts as in stooping.

The PRESIDENT—I think the seams that the deputation saw were mostly thick seams, none under 3 or 4 feet, although it runs in my mind there was one 3½ feet, where they took 2 feet of fireclay out from below, which made it a 6 feet working.

Mr R. T. MOORE—The seam in one of the Manchester pits was 4 feet, and 3 feet of fireclay was taken out from below all along the wall, and built into the side. By doing so, a very much larger percentage of round coal is got than in the system previously in use when the holing was immediately under the coal. There was a soft piece of holing 2½ feet down, so it was easier to take up the two feet of "blaes" and throw it into the waste.

Mr ALEXANDER—There are a great many thin seams being worked in this district. I daresay some of the members here will be able to say something about that. They cannot boast as to the large outputs, and when a comparison is made as to the tons produced per life lost, this district does not shew well. It must be apparent, however, that, if you are working an 8-inch seam

and a man puts out 10 to 15 cwts. a day from it, to compare that man's work with one who is working in a 7-feet seam and puts out 5 to 6 tons in the same time is a mode of comparison that does tell either fairly or favourably for the thin seam district. However, many here are accustomed with both modes, and it would be interesting to have their observations upon the question.

The PRESIDENT—That is a very important matter, because really we are apt to say how many tons has been raised for each life lost, and I think some of you Ayrshire gentlemen should express your opinions upon it. If the material removed is 8 inches thick, and to get that you have to dig two feet in thickness, there is only one-third of the material worked appearing in the returns, and hence the quantity per man is less than in a 7-feet thick seam, where every particle is valuable. With some of you, the dross is left in, which is another point of difference

The Secretary reminds me it would be well not to close the discussion until Mr Drinnan and Mr Mungall are present. Without saying more than that I agree very much with what Mr Alexander has said, I daresay you all know the necessity for systematic propping—say one every three or four or five feet as the manager might dictate, according to the normal state of the roof—and that would certainly be a great improvement on what we are now doing. Without going the length of saying whether that or the deputy system is the best, I think such an experiment as the reporters advise would certainly have a very beneficial effect, and I hope the managers will take it into consideration and say how far it can be carried out and how far they could advise the owners to carry it out. Nothing comes with so disheartening an effect as an accident, whether a broken leg or even the slightest accident, and especially a death. Every one is anxious to have as few of these as possible, and if there is any system better than another it should be tried. If the system proposed by the gentlemen who formed this deputation, and who I daresay have conscientiously given their opinions, is best, I think it behoves us all to consider it and adopt it as far as possible. You perhaps cannot altogether adapt it to all places; but still if you would only think over it and see how you would advise your owners I have no doubt the paper will have done good in waken-

ing up their minds on the point. I only make these remarks seeing we have strangers amongst us, and—seeing we are adjourning the discussion just now—to remind you that we are very desirous of having the written remarks of any member who cannot come to our meetings. The Institute has, I think, done a good deal of good, and there is abundance of material for consideration. I hope all the members will try and do what they can, not only by paying their subscriptions, but by giving advice —working all hand in hand to arrive at the best systems.

MR M'BETH'S PAPER.

The PRESIDENT—We have still before us another paper—that by Mr M'Beth, who has given us a description of the minerals of Stirlingshire. I shall be very glad if there are any points which you wish to consider in connection with this very interesting and valuable section.

Mr DIXON—There is only one point I wish to speak on. It is in regard to that remark, "On the separate sides of a slip" (reads). Are there any really well authenticated cases where a sudden change in the character of a seam has been proved to take place at a slip? In the Hamilton district, for instance, it was always thought that between Larkhall, where the ell coal is good at the bottom and bad at the top, and Greenfield, where the reverse is the case, there was some slip which would form the boundary. That has been found not to be the case. The change takes place gradually. In another case, it was found that two seams were together to the rise and separated to the dip, and it was supposed the change took place at a slip which was known to intervene. In working down, it was found to be a gradual thickening of the intervening strata, and I have seen many cases of the same kind. It is a generally accepted idea in mining that these things take place at slips, but in my opinion they more frequently take place gradually.

Mr BRYDEN—Though well acquainted with slips, I never saw a slip alter the coal in its natural quality or character. The slip is of modern origin, and the coal was there before the slip

occurred. We may have slips of different ages, but generally the slips were made long after the coal was formed, and the character of the coal must have been owing to the conditions under which it was made at first.

Mr AUSTINE—I know an instance in Stirlingshire where, in No. 2 Pit, Gartdrum, after driving from the bottom, probably 30 fathoms, we got a slip which took one foot off the thickness of the coal, which was 2 feet 10 inches or so. I drove a long mine up the field, thinking I would get some thicker coal, but I did not.

Mr ROXBURGH—We have one slip that illustrates what was mentioned, in which the cherry and splint coal are separated by about a foot of stone. That stone goes off in the one direction to 3 inches, but towards a slip of 25 fathoms it increases to 15 inches, and beyond the slip the two coals are separated by two fathoms, so that the little coal is not worked on the other side of the slip at all.

A MEMBER—The same thing occurs between Kenmuir and Newton. There is a slip of 30 fathoms: on one side the main coal and pyotshaw are separated by 4 inches, and on the other (the Newton) side by 30 feet.

Mr JAMIESON—I know a pit in Lanarkshire where there is no slip, and while at one point the pyotshaw and main coal are close together, at a point below that they are 30 feet apart.

Mr BARROWMAN—"Facts are chiels that winna ding," and it cannot be gainsaid that such instances as noted by Mr Austine and others do occur, but I am inclined to think they are mere coincidences, because they occur where there are no slips as well as where there are slips. We cannot overlook the fact that the seam was there before the slip, and any change that occurs would, it seems to me, only be local, being due to the mechanical influences of the disturbance by which the slip was caused.

The PRESIDENT—I have known instances, principally in gas coal, where a slip of a few inches has altered the thickness of the coal by as many inches. Mr Barrowman may be right that the coal was all deposited at one time, but a difference in the quality and thickness of the coal to my knowledge has been in many instances incidental to slips.

The discussion was then adjourned till next meeting.

CLOSING REMARKS.

The PRESIDENT—I am not aware that there is any other thing to do, but I have only to say how much pleasure I have had in meeting you all here, and I hope the Council and yourselves will keep in mind to have those meetings at different places. They have been very useful to myself, and I daresay you will all agree that they have been agreeable as well as useful.

Mr BARROWMAN—There is one little matter that ought to be referred to. You are aware that we got lunch at Burns' Cottage without paying for it, and I think it is due to the gentleman that provided the lunch that we should thank him for it. He is a coalmaster in the neighbourhood. (Applause.)

On the motion of the Secretary, a vote of thanks was also accorded to the President for his conduct in the chair, and the agreeable proceedings terminated.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 15th SEPT., 1881,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

RALPH MOORE, Esq., President, in the Chair.

The Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for and admitted as Ordinary Members :—

JOHN G. C. HAMILTON, M.P., Dalzell, Motherwell.
JOHN WILSON of Alderston, Mid-Calder.
THOMAS SPOWART of Broomhead, Dunfermline.
JAMES GILMOUR, Coalmaster, Elmbank, Kilmarnock.
ALEXANDER WEIR, Coalmaster, Auchinleck.
WILLIAM WEIR, Coalmaster, Caldercruix, Airdrie.
JOSEPH GILMOUR, Coalmaster, Goatfoot Colliery, Galston.
JOHN G. STURROCK, Coalmaster, Skerrington Colliery, Hurlford.
JAMES G. MITCHELL, Salesman, 175 Hope Street, Glasgow.
WILLIAM LOVE, Shotts Iron Co., Shotts.
THOMAS MOODY, Devon Colliery, Alloa.
JOHN SLOSS, Auchlochan, Lesmahagow.
WILLIAM SCOBIE, Manager, Barr Colliery, Beith.
JOHN RANKIN, Jun., Manager, Drumgray Colliery, Airdrie.
WILLIAM HASTIE, Manager, Gilmilnscroft Colliery, Auchinleck.
ROBERT PETTIGREW, Colliery Manager, 66 Flowerhill Street, Airdrie.
JOHN REID, Colliery Manager, Loanhead House, Baillieston.
WILLIAM HOGG, Colliery Manager, Carnmoor Cottage, Forth, by Lanark.
HUGH PATERSON, Colliery Manager, Braidhurst, Motherwell.
JOHN LEGGATE, Colliery Manager, Birkenshaw, Larkhall.
GILBERT M'PHERSON, Manager, Tribbock Colliery, Coylton, Ayr.

ROBERT GIBB, Manager, Pollock Colliery, Pollockshaws.
DANIEL GILMOUR, Manager, Portland Colliery, Kilmarnock.
ANDREW YATES, Manager, Bellfield Colliery, Hurlford.
ARCHIBALD CUNNINGHAM, Colliery Manager, Eglinton Iron Co., Dalry.
THOMAS CAMPBELL, Manager, Spindleside Colliery, Cleland.
JONATHAN C. WALTON, Manager, South Benwell Colliery, Newcastle-on-Tyne.
JAMES BARROWMAN, Colliery Manager, 16 Union Park, Bonnyrigg.
NICOL M'CAIRN, Colliery Manager, Prestonlinks, Prestonpans.
WILLIAM M'CULLOCH, Colliery Manager, Linkieburn House, Muirkirk.
THOMAS ANDERSON, Manager, Kirkwood and Drumpark Collieries, Coatbridge.
ROBERT DEWAR, Manager, Harthill Colliery, Whitburn.
DAVID FULTON, Colliery Manager, Dalquharran, Maybole.
WILLIAM TURNER, Manager, Chapel Colliery, Newmains.
JOHN M'INTOSH, Manager, Blairhall Colliery, Culross.
GEORGE SHARP, Manager, Duchray Colliery, Coylton.
WILLIAM SEMPLE, Sen., Manager, Goatfoot Colliery, Galston.
JAMES SMITH, Assistant Manager, Blantyre Colliery, Blantyre.
WILLIAM M. PENMAN, Oversman, Blairingone Colliery, Dollar.
WILLIAM MARTIN, Oversman, Douglas Park Colliery, Bellshill.

Other fifteen gentlemen were then nominated as Ordinary Members, and will be balloted for at the first meeting.

THE REPORT ON FALLS FROM ROOF AND SIDES.

The PRESIDENT, in announcing the resumption of the discussion on this subject, said a good deal had already been said upon it. The committee, he added, have expressed themselves pretty clearly, and I think they would be justified in saying unless you show some reason for objecting to anything that they have said that you agree with their conclusions. Perhaps Mr Drinnan, as he has now seen the Transactions, will say if he has any remarks on the subject so far as the discussion has gone. I may say that Mr Mungall cannot be here to-night.

Mr DRINNAN—I have first of all to say, Mr President, that I

was very well pleased with the way Mr R. T. Moore acquitted himself in the way of giving answers at the Ayr meeting. I was sorry circumstances prevented me from being present, but I am sure the members did not suffer anything by my absence. There was only one thing he said to which I should be inclined to take exception. From the greater knowledge I acquired by experience when in England, I know that the miners had reasons for holing deeper than we are in the habit of doing than the mere laying of the road. At p. 167, Mr Moore says:—"The deep holing" (reads). I made some reference to that at the meeting previous to the Ayr one, and explained the reason why the collier was so anxious to take the broad fall with him. The reason is that he has to lay a road along there; he has to lift it again when the cut has been taken to the far end, and it is a great advantage that he should get a 6ft. fall; and he will take it if the state of the roof will admit and the deputies will allow it, because he has only to lay and lift the rails once for a cut of 6ft., while if he took 3ft. he would have to do it twice. In addition to this, he has three or four pack walls to build in the distance of 30 yards. Well, he has these four or five walls to lengthen every time he takes a fall across and a facing building to put to each, so that there is a considerable saving of labour by taking 6ft. along with him instead of 3 feet. That is the only thing I can add to Mr Moore's explanation, and of course that knowledge I acquired by actually working in the district referred to.

The PRESIDENT—That is a very much better explanation, because it amounts to this—the collier has the fewer times to be at his buildings. As to the previous discussion, it will be remembered Mr Dixon took the trouble to ascertain the number of tons got out per yard, from which he showed there was a disadvantage in wide walls as compared with walls such as we have here, because you got more coals out of the length of wall with short walls than with long walls. Is that your experience?

Mr DRINNAN—Mr Dixon and I are entirely at one as regards that, only he has taken the trouble of going into the matter and showing by figures that ours is the least expensive, because the winning of the coal was much more quickly accomplished. I had the same opinion without going into the matter, and I expressed

that opinion during the discussion at a previous meeting. I may explain that I have a letter here which Mr Mungall has sent to Mr Moore, and he, being unable to be present, has handed it to me. He gives statistics to show that the East of Scotland district is in the forefront with regard to safety, 15 lives being lost by falls of roof per 12,146,443 tons raised. I think those points Mr Mungall has called attention to have been noticed in the discussion, and have been taken up by some of the members.

The PRESIDENT—If we are to have no more remarks, perhaps the discussion may be closed, and I think we should give the committee a hearty vote of thanks. (Cheers.) They took no end of trouble and spared themselves no labour in order to make the report satisfactory, and I am certain it is not their fault if it is not complete—they did everything they could for it.

Mr DRINNAN—Mr President and gentlemen, in name of Mr Mungall and Mr Moore, I have to thank you for the very kind expression of thanks for our labours in connection with this report. I must say, while we were going through those collieries, from the way we had to hurry about from place to place, I was afraid the report might not be altogether satisfactory; but thanks to the immense amount of labour Mr Moore has taken in connection with it, it has been perfectly satisfactory to myself, and I am glad to learn it has also been satisfactory to you. Mr Mungall also wishes to say that he is sure Mr Moore is worthy of our thanks for the great trouble he took in the preparation of this report; and I do believe it is altogether impossible for members to over-estimate the extent of that labour which he has done most admirably. (Cheers.)

The PRESIDENT—I shall take care to tell Robert, my son, how kind you have been in recommending him to notice; but I am satisfied if there is anything in the report it was owing to the judicious selection of practical gentlemen for the work, and I am thoroughly satisfied that the Council never made a more judicious selection than in fixing on the two gentlemen they did.

I hope that although the subject is finished here it will be kept in your minds, and that you will do something in regard to it. I may say that I have had from one manager of an ex-

tensive work an application on this point. He proposes to put in his special rules that the props shall be not more than five feet apart and sprags not more than five feet apart, so as to have uniformity throughout. I do not know whether the report has had to do with it or not, but it seems to me a step in the right direction. I think the words in our special rules are that "props and sprags shall be put up wherever the manager, overman, or fireman may direct." Very well, if he notifies by a special intimation on each pit-head that the distance between the props shall be so much—5 or 6 feet as may be deemed proper, I think, without any alteration on the rules, the owner has got the power to carry out the Committee's recommendations.

MR M'BETH'S PAPER ON STIRLINGSHIRE MINERALS.

The PRESIDENT announced that the next paper for discussion was Mr M'Beth's on "Stirlingshire Minerals." Mr M'Beth was present, and would be able to explain any point that might be raised.

Mr M'BETH—I have nothing to add further; but if any of the gentlemen have anything to ask about it, I will answer them in detail as well as make remarks on what has been said at former meetings.

No questions being put,

Mr DIXON, in proposing a vote of thanks to Mr M'Beth, said he was sure they must be all very much pleased, and must acknowledge heartily the great trouble Mr M'Beth must have taken in compiling these facts. Indeed, it is a paper of facts, and, therefore, any discussion upon it cannot be of any great length. He had much pleasure in proposing a vote of thanks to Mr M'Beth.

Mr M'BETH—I heartily give you my thanks for this vote of thanks. The only thing that I regret about the paper is that it was not worth more. It (the section) certainly has been greatly altered since it left my hands, and if by Mr Moore, he deserves more of your thanks than I do.

Mr JOHNSTONE'S NEW PUMPING ENGINE.

The PRESIDENT, in introducing the continued discussion on Mr Johnstone's paper, stated that Mr Johnstone had taken the trouble to bring a model of his machine, so that they could see it in operation. If any one had any question to put, he would be very willing to answer them.

Mr JOHNSTONE explained that the model was not the pump itself; it was a meter and worked by the same arrangement and valves with less than half a pound of water. He illustrated this by causing the model to work by merely blowing into it, and also again explained the theory of his engines by reference to large diagrams on the wall. In reference to there being two cylinders on the model, he explained it was not necessary but desirable, though he did not think people were educated up to the point of adopting the two, as they were dearer at first. The cost would be perhaps about 50 per cent. more and they would last a hundred per cent. more.

The PRESIDENT—Mr Drinnan, I think you have tried some kind of pump; what is your experience? Can you say anything about it?

Mr DRINNAN—I cannot say very much about it other than that we have one of Hastie's at work in one of our pits. We take the water from the main column of a forcing lift which goes down the shaft between 40 and 50 fathoms, and from the bottom of that lift we have 5-inch pipes to the bottom of the shaft and along the mine for 100 yards or so, then for other 200 yards it is taken in 3-inch pipes to the dook where the engine is at work. The engine is stationed about 30 yards down a dook, which has a dip of one in 10, and it lifts its water about 30 yards further down the inclination of the seam, being barely as much below where the pump is, and it is giving pretty good satisfaction. It is just now going at 13 strokes, the growth being not at all equal to what it could do, but we keep it going on air without other attendance than the fireman and roadsmen looking at it occasionally. The dook the engine is pumping the water from had been temporarily abandoned and a force pump left in with all the pipes attached. When I got the engine, I

thought it would effect a considerable saving if I could draw the water through the pipes already laid, and so I attached the engine at the top of the dook to the end of the pipes, and was able to take it out in that way. With the water out, I was able to run it down to where it is presently stationed, and this was easily done, as the engine is fitted on to a carriage with wheels of the same gauge as our hutches, and I made a side place off the road to run it into. The feed pipes are taken down the side of the road, and though there is some little noise in working, the horses go past without difficulty drawing the hutches up the dook. Since seeing Mr Johnstone's paper, I made some little calculations as to the proportion of feed water it takes for the amount of water actually discharged, and I think about two-thirds of the work it does is useful work. When going at 13 strokes, it is pumping nearly 24 gallons, and nearly 8 gallons of that is feed water. Of course, if we were going at a higher rate of speed we might not be getting so much useful work.

Mr JOHNSTONE—What was the distance of the heads from the discharge pipe to the force pipe?

Mr DRINNAN—I said it was down the dook about 40 yards,—about 12 feet lower level than where it discharges. Of course, a great deal depends on that.

Mr JOHNSTONE—What was the height of the head above the discharge pipe?

Mr DRINNAN—About 75 fathoms, very nearly 200 lbs. pressure.

The PRESIDENT—There are a few more calculations come in. I rather think the stroke of your pump is less than the stroke of your cylinder?

Mr DRINNAN—No, it is more. The stroke of the pistons of the cylinder is variable, but they will average about 4¼ inches. The stroke of the pump is actually 10 inches with an 8-inch pump.

The PRESIDENT—Are you only lifting vertically something like 12 or 15 feet?

Mr DRINNAN—The dook is actually down about 70 yards altogether, but the dip is not so much below the pump. Altogether it will not be over 20 feet lift and discharge at present.

The PRESIDENT—You find that it works satisfactorily without any attendance?

Mr DRINNAN—There is no attendance.

Mr MACCREATH—Mr Johnstone, how much water do you use in addition to that driving the piston in the cylinder?

Mr JOHNSTONE—That little cylinder gives eight strokes per gallon of water, or from five to ten per cent. of the water raised. A 3-inch cylinder will do almost anything.

Mr MACCREATH—Does no water escape?

Mr JOHNSTONE—There are leather washers, and by merely taking out the valve and giving the leather washers a tap with the hammer they are made tight.

Mr MACCREATH—With the machine going at Spindleside, you appear only to be getting 1-15th of useful work.

Mr JOHNSTONE—It is not at its work yet. I can guarantee 60 per cent. of the work if my instructions are followed out.

The PRESIDENT—It is capable of doing more work than it gets?

Mr JOHNSTONE—They could not put it full on without driving it to pieces—at least I would not guarantee it at the speed.

Mr MACCREATH—That shows it cannot adapt itself to the work required.

Mr JOHNSTONE—I do not know for any particular work. I make every pump for what it is to do permanently.

The PRESIDENT—In short, you make a smaller piston,—there is no other way of doing it?

Mr JOHNSTONE—Yes. The small engine has really nothing to do. There are the two buckets on the one rod, having more pressure on the one which gives it motion; that is if the area of the piston × lbs pressure of head is in excess of the area of bucket × lbs pressure of its head + friction. We must get motion, the velocity in proportion to the difference of foot pounds.

The PRESIDENT—It still comes to this that whether a hydraulic pump has much or little work to do it takes the same quantity of water to do it; but, even with that deficiency, the pump may still be a very useful one provided it works well. There are two things which strike me, viz., first, this piston with the dirty water which it would get here and here (pointing). I do not quite agree with you that the piston would be so tight as to clean it, because if you have sandy water it scours it.

Mr JOHNSTONE—I am sorry to say that it is practical experience I am giving. (Laughter.) It was a great cause of anxiety to me at the time. The water ran along 60 fathoms of nearly a flat road from the delivery pipes. When the road was being made the half of the water came back the dook, and I found that two or three pounds of coal had got in and choked the engine valves. Some of them I could not get out; I had to break them so that they would get through the valves, and the piston came up and crushed them into dross and sent them up the discharge pipe. Another way to work those pumps would be if you have a variable pressure to put on a lever with different centres and give a variable stroke as required; but I do not believe in levers, because the most of the friction is in the stuffing box, and that would require two stuffing boxes with heavy pressure exposed to the atmosphere; thus you are bound to get a lot of leakage.

Mr DRINNAN—I understand Mr Johnstone to say now that that dook at Spindleside is in course of extension. If that be so, I must have misunderstood Mr Jamieson whom I saw to-day. I was asking him about it, wanting to know how it would work when drawing in air. He said it was not doing that, but pumping from a certain point; and I rather fear Mr Johnstone must be labouring under a mistake.

Mr JOHNSTONE—The engine is at present fixed at one hundred fathoms down the dook. They are down nearly another hundred, and are preparing to place the engine there. The water is being pumped from the lower portion of the dook by hand at present. The Dook falls about 1 in 20, but gets flatter near the bottom. They tried to draw the water from 50 fathoms below the engine but, as the fall was fully 22 feet vertical, the vacuum was not sufficient to draw the water fast enough through 50 fathoms of pipes and lift the valves, which are very heavy, besides the valves of a hand pump through which it was drawn. It overcame the growth but did not make much impression on what had collected, so they resumed the hand pump for the lower portion till the engine is shifted.

The PRESIDENT—How did it work on air?

Mr JOHNSTONE—It goes quicker. I would never connect the

main supply to the engine in sinking, but have a small wrought iron pipe the bore of which would not pass sufficient water to let the engine endanger itself.

Mr DRINNAN—That may sound very well in theory, but we as practical men would like to know how it would work under certain conditions; and I would like to know if you have an engine going under the conditions I have referred to?

Mr JOHNSTONE—There is nothing about the pump different from any other pump. It is made with clack valves, and I could put in any kind of valves. The engine might go too quick and perhaps might not break itself, but I do not want them to go too quick, and to prevent that when in air, I put in the malleable iron pipe referred to, and it could not go too quick to hurt itself. There is nothing particular in the valves except they are the valves that are used in the best marine pumps. They are very expensive, but they are good valves, and will work for years without being renewed.

Mr DRINNAN—The reason why I put the question, which I am afraid will have to remain unanswered, is, we had some trouble with our engine. When going on air, the growth is not nearly equal to what the engine can do, and going at 20 strokes it would take out 12 hours' water in 1¼ hours. Consequently, when the men are working, it does draw in a good deal of air, and the valve on the receiving side frequently stuck and the engine would not pump. That troubled me a little, until I improvised a kind of "snifter" valve on the cover of the receiving valve and since that it has worked satisfactorily. I simply wanted to know how Mr Johnstone's engine would work under the same conditions, but I rather think he has not an engine working on the same conditions.

The PRESIDENT—I think Mr Johnstone's remark was that he took care not to let the engine go too hard by making a very small opening into his pipe so that the supply of water was restricted and the engine would not go fast though there was no work doing at all. What Mr Drinnan objects to is that when she gets on air the pump itself does not work well. I think that is a thing Mr Johnstone's attention has not been called to, but

that "snifter" valve is as old as time. Another is to have a pipe to let water run back or to leave a small hole in the bucket lid.

Mr DRINNAN—I may say I at one time thought I would let some of the feed water down but did not like the idea; and as Mr Johnstone has arranged as regards his, I got a special malleable iron pipe, which discharges in the same way as Mr Johnstone's does.

The PRESIDENT—All these things go to show that "necessity is the mother of invention."

Mr DIXON—This plan of pumping by hydraulic pressure is a very good one, and must be very simple. I would like to know if there is any other member present who has experience in that method of pumping besides Mr Drinnan, and can compare Mr Johnstone's engine with others. I think in many circumstances in mining operations besides dook driving such pumps could be used—such as pumping up blind pits from one seam to another, &c., and it is desirable to get the best and most efficient engine for doing so.

Mr CLARK—There was one at Arniston, but Mr Johnstone's has been attended with better results than we obtained there. It took 60 fathoms of a head to pump 30 fathoms. The hydraulic is larger than the pump by 3 inches, but we did not require that for useful effect. On the one end of the cylinder there is a 9 inch piston with a 5 inch piston rod, and on the other a 9 inch piston. The pressure is always on the end with the small area of surface exposed, and this is what causes the unequal pressure at the two ends of the cylinder. It works very satisfactorily. It is about four years since the first was fitted up, and it worked so well that we put in another 100 fathoms further down the incline to deliver to this pump.

Mr MACCREATH—Perhaps Mr Clark would inform us as to the length of pipes both for the supply and discharge of that pump?

Mr CLARK—There are 160 fathoms of pipes in the shaft and incline, and 100 fathoms of discharge pipes.

The PRESIDENT—Does the engine discharge into the sump so as to be pumped by the big pump?

Mr CLARK—Yes; it is discharged into the bottom. The driving pipe is a 5-inch pipe and the other a 6-inch pipe; it was working very well.* It was an English firm that fitted it up. There was first one fitted up and afterwards another. Before that, we drew the water with large water boxes by the winding engine.

Mr MACCREATH—When you have very long lengths of pipes, there must be a great loss of power with the momentum. With regard to the Spindleside pump, I have a few calculations, and at 45 feet a minute the loss of the momentum with 3 inch supply pipes was about four times the useful work done.

Mr JOHNSTONE—That is one of the reasons why I want the double engine and both cylinders of one size; but as I have said people are not yet educated up to that point. These engines would also be double the weight, and not so handy for shifting about.

The PRESIDENT—But still if you have two cylinders is not there a loss?

Mr JOHNSTONE—No; when the covers over the valves are put on, the water runs out of the discharge pipe as freely as it is possible for it. The water pipe in my office can only run 4½ gallons per minute, and when I work one of my engines with it, each stroke being ⅛ of a gallon, it makes no difference in the quantity of water run per minute*, showing the shifting of the valves does not absorb any of the power, and the flow of water is perfectly constant; for, when the valve of one engine is being closed the valve of the other is full open, and when once started it is impossible to put them on a dead centre. The little engine shifts the valve with a speed of 60 to 80 feet per minute, so that it is impossible to detect the pause in reversing.

Mr DRINNAN—We have put on an air vessel to lessen the force of the action referred to.

Mr DIXON—Mr Johnstone's two cylinders will save the shock.

The PRESIDENT—Three will do it.

Mr JOHNSTONE—In the case of these two, when one is being closed, the other is being opened.

* I have put a glass tube open to the atmosphere 18″ long on the pressure side of one of my models, with 35 lbs. pressure on the square inch, and the water will work the engine and shift the valves and not rise over a foot in the tube. I will be happy to show any of the members this experiment.

The PRESIDENT—But if three, it would be better?

Mr JOHNSTONE—No, it is not necessary. The valves in the model do not cut off, but in cases with heavy pressure they must be lengthened.

The PRESIDENT—I think you must admit there will always be a little loss of momentum—a little danger of it at the end and beginning of the stroke.

Mr JOHNSTONE—The velocity of water is only = to 12 feet of head at Spindleside, and suppose it was all lost it would be but a trifling percentage, but there is little or no loss.

Mr DRINNAN—I do not know but what he could maintain that argument of his, that the force is stored in the pipes; if he had an air vessel sufficiently large, the force spent would compress the air, the reaction would partly restore it.

Mr JOHNSTONE—In some hydraulic rivetting machines, the momentum is taken advantage of, as it acts like a dead blow, for closing up the rivet; but such sudden stopping is very bad for joints, and requires very strong pipes. This is the great advantage of having pipes of large diameter, so as not to travel the water more than 2 to 3 feet per second; then momentum may be taken as nil.

Mr BORLAND—In the event of a pump being put in, and ultimately found to be too large for the growth of water, what would be the effect of using a "cataract" for regulating the velocity of the pump?

The PRESIDENT—That is what Mr Johnstone explains. Still the same power would be expended. Water is an incompressible body, and you would have to fill it (the cylinder).

Mr BORLAND—You would have the same momentum stored in the water, but within certain limits. By regulating the orifice between the "main" and cylinder, the velocity of the pump will be accelerated or retarded according as the diameter of the orifice (squared) is greater or less, and would be more effectual in grappling with the "cause" than trying to remedy the "effect" of the valves sticking when the pump goes on "air;" and by a very simple piece of mechanism this orifice might be regulated by an automatic valve, which would entirely prevent the pump getting air.

Mr DRINNAN—I do not know if he understands the question, but he would understand it if I were to say we have three valves, or stop-cocks, one at the bottom, an intermediate, and one at the engine, and I have been careful to keep the one at the bottom and the intermediate sufficiently open to have the full pressure on the stop-cock at the engine, and it is opened just sufficiently to keep her going at sufficient speed to meet our wants.

Mr JOHNSTONE—I could make this small valve (shewing) to act as a cataract, so as to reduce the velocity with which the small piston travels. The big piston does that of itself, and that was the beauty of the double engine.

Mr DRINNAN—There is one difficulty, viz., the working of our pump is not regular; so we would have a difficulty in regulating it, as this gentleman says.

Mr MACCREATH—What is the maximum velocity of Mr Johnstone's pump as compared with the mean velocity?

Mr JOHNSTONE—It is always the same,—that is the beauty of it. It is the same all along,—not like a crank.

Mr MACCREATH—It must start at nothing, and be accelerated for a certain period.

Mr JOHNSTONE—It is so little you could not take it into account. The little one is working 100 strokes a minute. It is so inconceivable that for any practical purposes it is not worth taking into account.

Mr CLARK—I was very much surprised at Mr Johnstone's statement as to the dirt. I have assisted at fitting up three, and that was the greatest difficulty, viz., getting clean water to drive the pump.

Mr JOHNSTONE—I have given you the condition of the pit, and the pump sent out the coals I have mentioned.

Mr M'BETH—Given 500,000 gallons in 24 hours with 20 feet of head, could you manage to lift 10,000 gallons 200 feet?

Mr JOHNSTONE—I could not lift it with 20 feet of head. I do not guarantee the pumping engines to work under 10 fathoms head. It took me a good deal of time to adjust the valves of the model before I got it to its present state. I could make an engine to work with 10 inches head as the model does, but it would not repay the time and labour.

Mr BEGG asked what proportion the supply pipes bore to the cylinder ?

Mr JOHNSTONE—About a third of the diameter comes in very near, or a fourth—a third if it is a very long pipe. If a hundred fathoms, perhaps a fourth might do, but more than that a third.

The PRESIDENT—Mr Johnstone has explained his machine very clearly. You have, first, that the machine works satisfactorily itself without any attention. That is one point which no one seems to doubt. The next is that the piston in ordinary water will give little trouble. Another point is that you have got only one stuffing box, and that is so easily arranged that Mr Johnstone does not anticipate much trouble. The next point is that the valves are those of an ordinary pump, and you get 60 per cent. of the power of the engine—that is to say, if you have 100 feet of a head of column, you get at least 60 feet. An objection, it seems, is, if the pump gets air under the engine what scheme do you use to prevent breakage ? Well, Mr Johnstone says he puts in a small pipe, so that the piston won't go fast, because the water does not follow quickly up. That gets over the difficulty. The great thing which strikes us all is, if you are going to use it as a permanent thing, you have no power to expand like a steam engine. You must get an engine made for the work itself or put in those liners you speak of, and while that is a great objection for permanent use, still for any temporary use, or pumping small quantities of water, there can be no doubt it is a very valuable invention, and capable of being extended greater than we think of. There is no danger about it, no steam to do harm. There is water, which, as everyone knows, is practically incompressible, and one of the most tractable powers we have. With your leave, I propose that we give Mr Johnstone a vote of thanks for bringing such an important subject before us. (Cheers.)

Mr Johnstone briefly returned thanks.

THE ELECTRIC LIGHT AT EARNOCK COLLIERY.

The SECRETARY (Mr Gilchrist) made a verbal statement as to the progress of the electric light at Earnock Colliery. He said

at the time the members visited the Colliery, a great many, he believed, were dissatisfied owing to the state of the light at the time. Mr Bennett tried to explain how this came about, but he (the Secretary) thought they made a mistake in trying to concentrate the whole of the light into the bottom of the shaft so as to allow Mr Annan to take some photographs. He thought that was a mistake, for they did not allow themselves time to distribute the light properly. However, that was a thing they ought to have seen to before that. Next day they came out and they started the machine, and the lamps were burning for six hours. On the 13th, the next day again, the lamps were burning for about the same time, six hours ; and, ever since then, they had been burning the light for the whole of the time they were at work, viz., 10 hours a day, or 60 hours per week. They had, therefore, had it lighted for 282 hours. He might say, the engineers improved the light very much a few days after it was started, although he did not consider that it was what it should be. Mr Swan said, when describing it in the Glasgow Philosophical Hall, that each lamp would give about 50 candles. At Earnock, the average candle power of each lamp did not exceed 15 candles: on rare occasions he had seen it equal to 20 candles. Last week, he wrote to Graham's people complaining of the light, and asking them to try and make it better. They had that week sent out an engineer, and he was under the impression that day that he would make it better. To assist them in that respect, they had given up the lamps at the face. One reason for that was this, that the miners' lamps were placed 600 yards further in than the inside lamp at the pit bottom, and to force the current into these lamps, they had to put resistance coils on to every lamp at the pit bottom. Of course, that was a loss of power. Therefore, seeing the light was not as good as it should be at the bottom they resolved to do away with the miners' lamps at the working faces. They had thereby been enabled to reduce the speed of the engine considerably without loss of light. Before last week, the engine was running about 92 revolutions per minute, and the dynamo machine 1510 to supply 16 lamps at the bottom, and four at the colliers' faces. As for broken lamps, Principal Jamieson said the maximum life of the lamps was 400

hours, and the minimum life 300 hours. Since the members visited the colliery, 10 lamps had given way out of the 16 that were placed in and near the bottom. Two lamps broke on the 25th August, after giving light for 112 hours ; 5 more gave way on the 7th September, after burning 222 hours ; 1 on the 8th, 10 hours ; 1 on the 10th, 130 hours, and another on the 13th, after burning for 50 hours. One lamp had broken twice, and another had given way three times, so that 9 of the first lamps were still giving light.

The PRESIDENT—When you speak of the "lamp" breaking you mean the small carbon filament ?

The SECRETARY—Yes. Not a single glass had been broken, but the carbon filament had given way in all cases. The lamp was useless after that. He might further state that during the time the colliers were working with the lights at the face, it was rather forced work with them. They preferred the ordinary open lamps ; but one and all of them admitted that they would be better than safety lamps ; only, seeing they had wires attached, they could not carry them about as readily as the little oil lamp, and they preferred it.

The PRESIDENT—What is the amount of attention required?

The SECRETARY—There is very little attention required. What was necessary was mostly in connection with the engine, and if the brushes were kept well on the dynamo machine that was all that was specially required. They had a man looking after a boiler and engine before, and this was a little additional work for him. There was no attendant in the pit. The engineman in the morning started the engine for driving the dynamo machine about a quarter past six and the whole thing was lit up, no one in the bottom requiring to put their hand to anything in connection with it. It glowed away all day until the engineman stopped the engine about half-past four at night, and when he stopped it the lights went out at once. One day, Mr Marr, a representative of Swan's people, called and looked over the place. In speaking of the lamp being broken in the gas to ascertain if the light would explode inflammable gas, on the day the Institute visited the colliery, he said he did not consider it a fair test at all. He asked if it was one of the mining lamps

they had broken, and on being informed that it was a little Swan lamp only, he said if the lamp had been enclosed in a lantern, similar to those fitted up at the working faces, that the blow that would break that would also break the carbon filament, and it would not be possible to ignite gas. He (the Secretary), from practical experience since, was rather inclined to think there was a little truth in this.

The PRESIDENT said that possibly this matter should be considered first as a light, and next a light applied as a safety lamp. There seemed to him to be a great deal in it,—if they could get an economical light,—as much for the surface lights as the bottom. That was the first application of it which it struck him they should consider: could it be done properly, satisfactorily, economically, and could it be relied on day after day; and after they had got that discussed then came in the question of the lamp as a safety lamp. Was it any better than the safety lamp, and how much, and what were the deficiencies about it? He thought they had got very little to do in the first case, viz., in considering it as a light. That would be his way of taking it. Look, for instance, at the accidents which happened where open lights were used about the bottom, the top of pits, engine houses and scaffolds. It was a wonder to him there were not more accidents from the careless way open lamps were carried about. What a wonderful light it was—they might use it without the danger of anything being burned. With gas, they might have leakages of pipes and want of safety in many ways, but with the electric light there was absolute safety, and even although it might not be safely adapted as a safety lamp it was a very great invention for lighting mines. He was much pleased to learn that it was doing regular work. When a man came at six o'clock, set his engine going and the light burned till night, really they had got an immense length already in the matter.

On the suggestion of Mr Barrowman, the whole matter of the electric light was referred to the committee on Safety Lamps; and after Mr Gilchrist had explained the small amount of power expended in keeping the light burning, the meeting adjourned.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 13th OCT., 1881,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

RALPH MOORE, Esq., President, in the Chair.

The Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for and admitted as Ordinary Members :—

DAVID CARRICK ROBERT BUCHANAN of Drumpellier, Coatbridge.
G. H. GEDDES, Mining Engineer, Edinburgh.
JOHN STEVENSON, Coalmaster, Dunfermline.
THOMAS GRIERSON, Coalmaster, Glebe Colliery, Douglas.
ROBERT GLEN, Agent, Eastfield Colliery, Rutherglen.
JAMES ALLARDICE, Manager, Eastfield Colliery, Rutherglen.
NEIL COCHRANE, Manager, Auchinheath Colliery, Lesmahagow.
JAMES SIMPSON, Manager, North Linrigg Colliery, Holytown.
HENRY ROWAN, Manager, Hematite Mine, Knockmurty, Cumberland.
JAMES RAMSAY, Colliery Manager, Morsely, Whitehaven.
ROBERT JAMIESON, Colliery Manager, Polkemmet Cottage, Bathgate.
PETER MORRISON, Manager, Spittalhill Colliery, Newton.
JOHN HUSBANT, Manager, Ibrox Colliery, Govan.
DAVID ANDERSON, Oversman, Little Raith Colliery, Cowdenbeath.
GEORGE ERSKINE, Oversman, Lochgelly, Fife.

Other five gentlemen were then nominated as Ordinary Members, and will be ballotted for at the first meeting.

ON GAS FIRING, WITH A DESCRIPTION OF THE WILSON SYSTEM.

By Mr F. J. ROWAN.

For some years attention has been directed to the various questions connected with the use of fuel, with a view to ascertaining and introducing the most efficient and therefore economical methods of combustion and of the application of the heat thus produced.

I have the pleasure of bringing before you one of the most recent and successful of these methods, and I propose to say a few words on the general principles of combustion, and then to describe the Wilson gas producer and one or two practical applications which have been successfully carried out.

This subject is one of considerable interest to those who are connected with mining, not only because they obtain our supplies of coal and are specially interested in all that affects its use by others in greater or lesser quantity, but also because in their own operations they have themselves to make a considerable use of that fuel.

I think it will be admitted, too, that while the production of smoke in towns is to be deplored and prevented as much as possible because of its many evil effects on health and comfort, in the country it is not less objectionable on other grounds. The aspect of picturesque country scenery in the midst of which coal mines are generally placed is too often disfigured by the volumes of dense black smoke which escape from the chimneys attached to boiler and other furnaces belonging to the colliery. As this smoke represents fuel wasted, there are also economical reasons why it should be abolished or prevented by proper methods of combustion.

(1). In burning coal it is now well known that there are two distinct series of operations taking place, viz. :—1st, the distillation of the volatile hydro-carbons and the production of gaseous carbonic oxide from the solid carbon combined with oxygen ; and, 2nd, the combustion of these gaseous products or their combination with a definite quantity of oxygen.

A definite quantity of heat is absorbed in the first series, a small quantity being also produced by the combustion of the carbon to carbonic oxide, and a definite but larger quantity is produced in the second series.

Where both series of operations are carried on in the same chamber or furnace it follows that the production of heat must rise and fall in waves or pulsations according to the state of the fire. In fact the presence of smoke is a witness that when green coal is charged into the furnace so much heat is being absorbed by the chemical actions of the first series mentioned, that there is not a sufficient amount obtainable, with the proper admixture of air, to burn the gases which are being (perhaps even imperfectly) produced.

Mechanical stokers have been introduced to remedy this state of matters by limiting the quantity of coal supplied at any one time and making this supply constant and even, and some of these have to a great extent succeeded in burning coal economically and preventing smoke. But they involve the erection of machinery of a more or less complicated nature, which also needs attention; and they are not pliable enough, because being set to the rate of feed which is found suitable for one quality of coal and one state of draught of air, if these are altered in any degree, the rate of feed of necessity becomes unsuitable and combustion is imperfectly carried on. Moreover, the two series of chemical operations are still carried on in the one furnace or chamber, and therefore heat is alternately abstracted and produced, although the pulsations are very much more frequent, and thus either too much or too little coal seriously alters the temperature produced.

There are other considerations arising out of the quantities of air required for the combustion of the various products which result from the distillation of coal, and these, combined with those just referred to, go to prove that firing with coal on the open grate, even with the refinements of mechanical stoking added, does not supply the best conditions for efficient and economical heating. Thus :—

		Cubic feet of air required for complete combustion.		
1 lb. Carbon	requires	... 158	...	to CO_2
1 lb. Carbonic Oxide	,,	... 32·4	...	,, CO_2
And of the Hydro-Carbons—				
1 Cubic Foot of Olefiant Gas	,,	... 14¼		
1 Cubic Foot of Marsh Gas	,,	... 9½		
While 1 Cubic Foot of Hydrogen	,,	... 2·38		

Now, in firing upon the open grate we are producing these gases and at the same time endeavouring to burn the carbon to carbonic acid, that is in the way which demands the greatest quantity of air. If, however, we burn the carbon to carbonic oxide in a separate chamber, this gas, when 1 lb. of it is introduced into the boiler (or other) furnace, demands only 32·4 cubic feet of air for its combustion, and under such circumstances we need not have any olefiant gas or any of the heavy hydro-carbons, but only a small quantity of marsh gas and some hydrogen. So that in this case the powers of chimney draught are not taxed in nearly so severe a degree. This is the effect of the use of the gas producer, which has the additional advantage that it enables us to produce a steady heat without any fluctuations or pulsations in amount, and it is also to be remarked that the best heating effects are produced by hydrogen and carbonic oxide, which are the main constituents of the gas from the Wilson producer. In the Siemens producer, on the contrary, the heavier hydro-carbons are produced and are condensed as useless tar in the cooling tubes.

(2). I come now to the description of the Wilson Gas Producer. It is, as will be seen by the diagrams (see Plate XXI.) and model, a cylindrical chamber formed by a shell or casing (A) of wrought-iron rivetted plates, lined with brickwork (B). This brickwork is so built as to form the straight or slightly-tapered barrel (C), the cupola portion (D) at the top, and the ports or passages (E) into the annular space (F) from which a pipe (G) branches off to conduct the gas to flues or furnaces.

The producer has a solid hearth (H) without firebars, upon which the fuel rests. This hearth is divided by the central tuyere casting (I) which, covered with fire-brick, forms a ridge extending across the centre. Through this tuyere air is forced by means of two small steam jets (J), placed at the top of the tapered vertical pipes or " throats " (K) which stand on the part (L) of the tuyere casting which projects through the producer casing. These steam jets are regulated by stop-cocks, and the throats have covers by which they can be completely closed, when the producer is not working. The producer is worked with dross which is fed in by the hopper (M) and bell (N) at the top, the

working surface of the fuel being maintained in the cupola portion just clear of the bell-cone in its position when lowered.

The air and steam forced in through the tuyere casting are delivered in the centre of the mass of fuel a little above the bottom surface of the producer. Here the steam acts by absorbing heat in its decomposition, thus keeping the bottom and casting cool, and preventing the fusion of ash and fire-bricks into heavy clinker, besides rendering the ash and small clinkers quite soft and rotten so that they are easily removed.

The air supplies oxygen which forms carbonic oxide with the carbon of the coal, and the steam also is decomposed into oxygen, which forms a further quantity of carbonic oxide and hydrogen. These gases, with the nitrogen of the air, pass up through the coal and into the annular space through the ports or passages which are spread round the circumference of the producer, and thence away to the main and other flues.

The green coal charged through the hopper is slowly distilled in the cupola part, and the hydro-carbon gases pass downwards through hotter carbon on their way to the ports. They are thus broken up into lighter hydro-carbons, and probably carbonic oxide and hydrogen, so that no tarry deposits are found in the flues leading from the Wilson producer.

Attention must of course be paid to the state of the coal while the producer is at work, and by means of poking it is kept from caking too much and forming passages through which either air or carbonic oxide could pass uncombined or undecomposed.

I must not omit to notice the cleaning doors (O) and the "crupper boxes," (P) and their use. These latter provide openings, one on each side of the producer, through which short flat bars are pushed until their ends rest on the central ridge. The cleaning doors are then opened, and the ash and clinker taken out from underneath these bars, which support the coal and prevent its running down and mingling with the ashes. When the ashes are removed, and the cleaning doors closed, the bars are withdrawn, and the fuel is poked down till it rests on the hearth again. The whole occupation of cleaning occupies about half-an-hour.

(3.) Having thus produced good heating gas, we have to consider the use of it in various heating operations. The operations

to which gas-firing can be applied are as numerous and diverse as are the instances of heating with coal fires on a large or small scale; but in the main they may be arranged in two classes.

The first is that class of operations which require only a moderate heat, not exceeding a bright red, in which we burn the gas by means of ordinary atmospheric air (*i.e.*, air of ordinary temperature) mixed with it at the combustion chamber by chimney draught.

In the second we have to deal with the higher heats required for burning-off kilns of bricks and pottery ware, and the melting of glass and steel; and for these we require a supply of air for combustion which has been heated to a considerable extent. It is here that great economies in the use of fuel have been realised by means of ingenious methods of obtaining this heat for the air from the waste gases which of course escape from the furnace at the temperature of the furnace itself.

As typical instances of these two classes, I take for the first the firing of steam boilers, and for the second the burning of fire-bricks.

The melting of steel in open-hearth furnaces is in some respects a more characteristic example of the second class, and it is not saying too much to affirm that this operation could not be successfully carried out without the use of gaseous fuel. So that here we have an instance of a new industry opened up by the introduction of gas-firing.

1st—The means of applying gas to the firing of steam boilers are very simple. They are to be seen in one form or another now in almost every iron work, having blast furnaces at work. The gas may be conveyed in flues either above or below the boilers. In the case of gas drawn from blast furnaces it is usually carried in pipes above, but when obtained from a gas producer of the Wilson type generally the most convenient arrangement is to have an underground brick culvert.

From the flue (wherever it is) the gas is led by a branch pipe (A, Plate XXII.) to the furnace door (B) where it is met by air sucked in by the action of chimney draught, through openings (C) made either in the door or above. These openings may be closed, wholly or partially, by dampers or

regulators (D) when necessary. The ash-pit opening (E) is closed and the fire-bars are removed except just at the front of the furnace, where a small quantity of burning dross is kept to serve as a sort of wick or torch to light the gas. This is merely a precautionary measure, as after the gas is once lighted, if the supply is kept up, there is a long curling flame continuously sweeping through the boiler furnace, and often appearing at the end of the return flues or tubes after having turned the corner at the back of the boiler.

The advantage of such a system of firing boilers is apparent. The boilers are steadily and continuously exposed to an even temperature and are not heated and cooled with every variation of the condition of a coal fire and the many occasions which it necessitates of opening the furnace door.

I am not prepared with figures giving actual economies from practice, in consequence of unwillingness on the part of those working boilers with gas to make the details of their practice known, but I am assured by several who have practical experience of this use of gas, that there is a marked improvement in the wear of boilers thus fired; repairs become less frequent, and the life of the boiler is prolonged.

Moreover, the quantity of steam raised from a given amount of heating surface is increased, and there is necessarily an economy in the amount of fuel used. When to these we add *no smoke*, and the convenience of flues kept clean and free from soot and ash dust, it is evident that there are very solid reasons in favour of firing boilers by gas.

In this class of operations I have recently carried out the application of gas to heating iron retorts for burning bone charcoal in sugar refineries, and I am about to apply it to the heating of oil stills.

The plate heating furnaces of engineers and shipbuilders come within this class, and also several chemical furnaces such as those to which gas from Wilson producers has been applied at St. Rollox Chemical Works. In these dross is now used where previously it was necessary to have coke as fuel.

2nd—Within the last three months, the Wilson producer has been successfully employed in the new application of gas which

I have chosen as typical of class 2, and at Mr Dunnachie's Firebrick Works at Glenboig, there may now be seen one of the most complete examples of the production of a very high temperature by the use of gas, along with a very thorough conservation of the heat produced.

Mr Dunnachie has special kilns or chambers arranged in series with communication between each chamber, as well as independently of each other with the chimney, and they are worked in rotation continuously. Thus say No. 1 chamber has been burned off, and is almost white hot, No. 2 is at this point nearly red-hot, because the products of combustion from No. 1 have been passing through it towards the chimney. The gas is now turned from No. 1 and into No. 2, and the air for combustion is drawn through the heated No. 1, abstracting its heat which is again found in the intense heat of combustion produced in No. 2. As in the previous stage with No. 2, the waste gases which now leave chamber No. 2 at the heat which it has reached pass through No. 3, and there gradually heat up the bricks from a cold state to a red-heat.

The economy in fuel and in the time of burning are proved to be considerable, being fully 50 per cent. in the one case and about 40 per cent. in the other. An account of this process is given in "The Iron and Coal Trades Review" of October 7th, in the London "Times" of Tuesday, and in the "Glasgow Herald" of to-day (13th).

I suppose that the action and power of the blow-pipe are familiar to all whom I address, and therefore mention that the use of gas has enabled Mr Wilson to obtain very high heats by ingenious methods of constructing the blow-pipe on a large scale. Even with cold air, it is by this method possible to melt very refractory materials, and with air moderately heated by waste gases, furnaces on this plan have been worked for melting pig iron and for welding operations.

In conclusion, I may remark that, although such improvements as I have now brought before you result in decided economies of coal, yet this does not necessarily mean a reduced consumption on a large scale. On the contrary, the possession of the means of conducting manufacturing operations cheaply gives the manufac-

turer the power of increasing both his sale and his manufacture, and this result is always sure to follow.

And thus it is that the surest road to increased amount and prosperity of manufactures is that of an enlightened appreciation of the principles involved in them, and of every advance in technical knowledge.

The PRESIDENT—In accordance with the regulations, this paper falls to be discussed at our next meeting after the paper is printed, but it will be well if any one has any questions to put, that they should put them while Mr Rowan is here. You will observe that in the first place the apparatus is for more effectually consuming the coal than in the common fire-grate. Mr Rowan has explained the matter so very well that I need say little about it; but there are one or two points I might suggest: What is the size of this machine? What size of a machine would it take to fire a boiler 30 feet by 5 feet? and how much coal would it save? also, how much would it cost?

Mr ROWAN—The size of the Producer that has been most generally adopted hitherto is about 10 feet high by 8 feet diameter. That is a Producer capable of working at the rate of 4 cwt. dross burned into gas per hour. It is possible to work a Producer of that size faster, but 4 cwt. an hour is found to be the most economical speed. The cost is £100—in round numbers—with Mr Wilson's royalty of £30 added to that. Applied to the firing of boilers, one Producer is equal to a little more than 100 horse-power. I cannot give in exact figures the economy of fuel in firing boilers by gas over hand firing, and in fact it very much depends upon circumstances. Some boilers are most carefully fired by hand, almost as well as is possible by mechanical means, and in such a case it is not so much a question of economy in fuel actually burned as of other economies. These, as I indicated, are the economies in the wear of the boilers and in the quantity of steam produced from the same heating surface. I believe in many cases, there has been an economy of something like 25 per cent. in actual fuel consumed for a given power; but we have found it very difficult to get any of those manufacturers who are firing their boilers with gas to tell us what they are doing as compared with what they did before. However, I am glad to say I have the promise shortly of

some very careful experiments to be carried out on a boiler fired by gas which hitherto has been fired by hand in the ordinary way.

Mr RONALDSON—Is it the case that while you are drawing off the ashes the flow of gas from the Producer is stopped?

Mr ROWAN—Generally speaking with a good chimney draught a sufficient quantity of gas may be produced to keep the furnaces going while the cleansing is proceeding; but without that if there is only one Producer, as the steam jets must be shut off, the production of gas is stopped for twenty minutes every twenty-four hours.

Mr HOGG—Might I ask if it would not be possible to draw the ashes out of the Producer in the same way as from oil retorts, and if that would not prevent the stopping of the air jet? In the retorts I refer to, the shale falls through the bottom of the retort and falls into a pan filled with water, so that they can draw off the spent shale without stopping, and I was wondering if it would not be a better way than pushing the bars through the Producer in the way described?

Mr ROWAN—The circumstances are so different in the case of the Producer, I do not think the appliance mentioned could be used. We are dealing with a large chamber 8 feet external diameter, or about 6 feet diameter inside, very different from a small retort which can be manipulated in the way spoken of. The material we are dealing with being dross, is very different from shale or gas coal; and another point is that in the case noticed distillation apart from contact of air is carried on, whereas we burn the carbon into carbonic oxide by means of access of a definite quantity of air.

Mr BORLAND—In regard to the regulation of the steam, is there any danger in forcing too much air into the gas Producer and forming carbonic acid gas? and, also, is there any gauge for testing the quality of the gas that comes out of the Producer?

Mr ROWAN—The size of the nozzles is so small that it is impossible to blow too much air into the Producer under ordinary circumstances. Carbonic acid is first formed, but it is decomposed or reduced to carbonic oxide before it escapes through the ports.

We regulate the size of the nozzles according to the pressure of steam, and give a certain size of nozzle with a given pressure of steam, so that only a definite quantity of air can be passed in. As to the testing of the gas, the best test is how it burns; because if carbonic acid is being formed, it will very soon put out the flame. In one instance recently, a Producer was found to be producing carbonic acid, and the fire was of course extinguished; but on investigation it was found that, in consequence of neglect, the Producer had become almost empty, the coal having caked and formed a crust near the top. There was almost nothing but carbonic acid being made, but that was the result of carelessness or negligence continuing during a whole night, and it was remedied by poking down the coke and filling in fresh dross.

Mr DIXON—There will be something like 2 tons of dross in the Producer: is it not a difficult thing the putting in of the bars?

Mr ROWAN—No, because when the time for cleaning has arrived the level of the ashes is above that of the bars, and the action of the steam is such that it is possible to drive the bars through the ashes by hand, a few blows of a hammer being necessary on rare occasions.

The PRESIDENT—What is the temperature of the gas when issuing out of the Producer?

Mr ROWAN—About 400° to 600° Faht.

Mr JOHNSTONE—Mr Rowan has mentioned the Siemens' Producer; I heard Dr. Siemens' lecture in Glasgow on one which was commended by Sir William Thomson, and which was able to work a gas engine. I would like to know if Wilson's is as good as that one; also, if they have attempted to take the ammonia from the products? This would be a very paying thing as far as I learn. As for heating with gas, most engineers who have examined the question know that in a very short time there will not be such a thing as a boiler fired with coal. It is a barbarism of the past, a disgrace to civilisation which will soon be done away with. The best retort and most economical way of using fuel is one of the greatest questions of the present day.

Mr ROWAN—I may say in reply to this gentleman, that I heard the lecture referred to but did not form a high estimate of the value of the design exhibited. I do not think that Dr. Siemens'

new producer is likely to succeed. It was ominous that when it was introduced for trial into the Glasgow Gas Works, the design was modified by the removal of all the special features on which Dr. Siemens laid stress in his lecture. I believe it has since then undergone further alteration and is no longer a Siemens' Producer. In a plan issued recently by Dr. Siemens I noticed that these special features were omitted also. As to using this Producer for gas engines, the matter is under the consideration of the principal gas engine makers. The gas is perfectly suitable; only there is a considerable quantity of nitrogen derived from the air mixed with this gas, and this would necessitate some modification in the gas engine. It is an important matter because, while engines using town's gas are paying from 3s 9d to 4s 9d per thousand cubic feet for the gas, the Producer can give them a gas which costs no more than 2d or 3d per thousand cubic feet. With reference to extracting ammonia from the gas, there is no ammonia in this Producer gas. There is a quantity of nitrogen derived from the air, but no means are as yet known of extracting this from the air, or of obtaining ammonia from it.

The PRESIDENT—You give 4 cwt. dross an hour as what a Producer will burn. That is just, I think, about one boiler, 30 feet by 5 feet. Our common egg end boilers are about 3 tons to 4 tons, so that you would need one of those for every boiler.

Mr ROWAN—I think you will find that two Producers can work three boilers. That has been found in working with other Producers.

Mr DIXON—Mr Rowan said 100 horse-power: an ordinary boiler is about 30.

The PRESIDENT—Mr Rowan will be calculating the expenditure of 2lbs. of coal per horse power, but we find it to be 15 to 20lbs.

Mr ROWAN—I allowed 4lbs. per horse power, which ought to be enough.

The PRESIDENT—I think it is only right to say about 15lbs. is as good practice as we have with our boilers and colliery engines.

Mr ROWAN—I am very glad to hear it, because it opens the prospect to me of being able to save 50 per cent. instead of a modest 25 per cent.

The PRESIDENT—I think at this stage we may leave the dis-

cussion till next meeting, and perhaps Mr Rowan will be kind enough to give us his presence so that we may have a little further discussion on it. The paper requires very much study and careful reading, and you will all be the better of it whether you take a Producer or not.

The discussion was then adjourned.

MINING SURVEYS.

By Mr T. LINDSAY GALLOWAY.

In the following paper it will not be attempted to give a detailed description of the various methods of surveying. The writer will confine his remarks to a few particulars, the discussion of which may perhaps be practically useful.

That branch of surveying which more especially concerns us as members of this Institute is, of course, underground surveying. The compass is not more indispensable to the sailor than the dial is to the miner; for by its guidance the miner, as it were, steers his course, giving a wide berth to whins, faults, and dangerous wastes, which are the reefs and shoals of mining. The use of the magnetic needle, however, is restricted in mines on account of the presence of iron, and especially rails. It is sometimes maintained that if a compass is placed upon a tramway exactly between the rails the needle will not be deflected on account of the iron having an equal attraction on all sides. But this is only true in certain positions. If the rails should happen to be lying north and south or east and west, the attraction of the iron will not disturb the needle; but if the rails are lying at an angle with the meridian, the needle will always be more or less deflected. Before one can depend upon the loose needle for accurate work, it is necessary to remove the rails for a distance of several yards

on each side of the compass; and to do so at every sight entails a great deal of labour, besides being detrimental to the roads.

For underground work, the system of surveying by angles and distances is the best in which the magnetic needle is employed only for the purpose of obtaining a meridian. This is done at one or more points at which there is no iron, or from which all iron has been removed. This method of surveying is called traversing, and can be most easily performed by the use of a compass provided with three tripods or stands. The three stands are placed in order along the line of survey; one having a light upon it, is set up as a back sight; the next carries the compass; the third, which also bears a light, occupies the foresight. After the observations have been made and the distance and offsets measured, the stand which formed the back sight is carried on to the front. The other two stands remain fixed; but the compass is moved a stage onward; so that the stand which it lately occupied now forms the back sight. In this way the survey proceeds from point to point, and when the men in attendance understand the routine it can be carried on with great speed and ease.

In this method of surveying it is of importance to have a simple and secure means of fixing the compass to its stand. The plan which the writer has found to answer best is to have an internal screw in the compass, with two or more portions of the thread slotted out. The screws on the stands are slotted in a corresponding manner, so that the compass can be slipped into its place at once, and a fraction of a turn will then secure it. This simple arrangement occurred to the writer a year or two ago, and it has since been coming into adoption.

With regard to the levelling of the instrument, there are several devices in use. One plan is the simple ball and socket; another is the arrangement employed usually in the spirit levels and theodolites, viz., two parallel plates with four screws—one at each corner. But the plan (see Plate XXIII.) which appears best to combine the advantages of speedy action and fine adjustment, is an American invention called Hoffman's Joint. This has four screws like the ordinary parallel plates; but when the screws are sufficiently released the head

of the instrument is free to move about inany direction. It can thus be placed nearly level at once; and when the screws are tightened up it is secured in that position. The fine adjustment can then be made by means of the same screws, and a mere touch is usually sufficient to place the instrument perfectly horizontal.

There are two ways of reading and booking the angles. In the one method, the back sight is always taken with the index on 360°; so that the angles measured are the actual angles between each pair of station lines. The other system consists in commencing with the zero line on north, and using one pair of slits in the vanes for the back sights and the other for the fore sights. After each fore sight the vernier plate is clamped, and the compass carried forward to the next station. The vernier being still kept fixed at the last reading, the instrument is turned towards the station just left. The surveyor now looks along the same line as before, but in the opposite direction. As, however, he is using the opposite pair of slits, the zero line will be still pointing in the direction which it had before the instrument was removed. The neck is now clamped and the vernier plate set free, and the surveyor proceeds with the next fore sight. Thus, if the zero line has been placed north and south at the commencement, it will remain in that direction throughout the entire survey, and the angles read will not be those which each station line makes with the preceding, but those which each station line makes with the meridian.

One advantage of the foregoing method is that the correctness of the survey my be tested at any stage of its progress. In order to do so, it is only necessary so remove all rails or other masses of iron from the neighbourhood of the compass, and it will at once be seen by turning the index to zero whether the zero line coincides, as it ought to do, with the magnetic meridian. Another advantage gained by this method is that the angles can be plotted at once upon the plan; whereas, if the zero is each time turned towards the last station, the angles so observed must be added together in succession and reduced to the meridian before they are plotted.

The simplest way of taking account of the magnetic

variation, so far as the writer is aware, is to have two stakes driven into the ground a couple of hundred yards apart, marking a fixed direction upon the surface and upon the plan. Before making a survey a sight should be taken from one stake to the other, and the magnetic bearing observed. By means of this, a meridian can be laid down upon the plan which will form a correct base line for any survey made at that date. When two or more shafts are available no magnetic bearings are required, as an underground survey may, of course, be connected with a plan of the surface by two or more points common to both. Unless, however, the shafts are some distance apart, so as to afford a long enough base line, it is not so easy to get satisfactory results by this method as by careful and repeated observations of the needle. There are several methods in use for connecting an underground survey with a plan of the surface when only one shaft is available without the use of the magnetic needle, but all those methods appear to the writer to be open to the objection that a very small error in the observation will become magnified and lead to great errors in the final result.

There is usually attached to mining compasses some arrangement for measuring vertical angles. Such additions are useful in the case of highly inclined strata, being sufficiently accurate to estimate the inclination for the purpose of reducing chain lines measured along a slope to the equivalent horizontal distances. For the purpose of levelling, however, they are insufficient. Where the roads are high and not too much inclined, the ordinary levelling instrument and staff may be employed with advantage for levelling, being much more reliable for long distances than the straight-edge and masons' level, which are frequently used. But in the case of a low roof and steep or crooked workings, the levelling instrument becomes troublesome on account of the great number of sights which require to be taken. To obviate this difficulty, Mr C. Z. Bunning and the writer constructed a levelling instrument which they described in the Transactions of the North of England Institute of Mining and Mechanical Engineers for the year 1878. The instrument consists practically of two glass tubes having scales attached and connected together by a long india-rubber tube containing coloured liquid. The

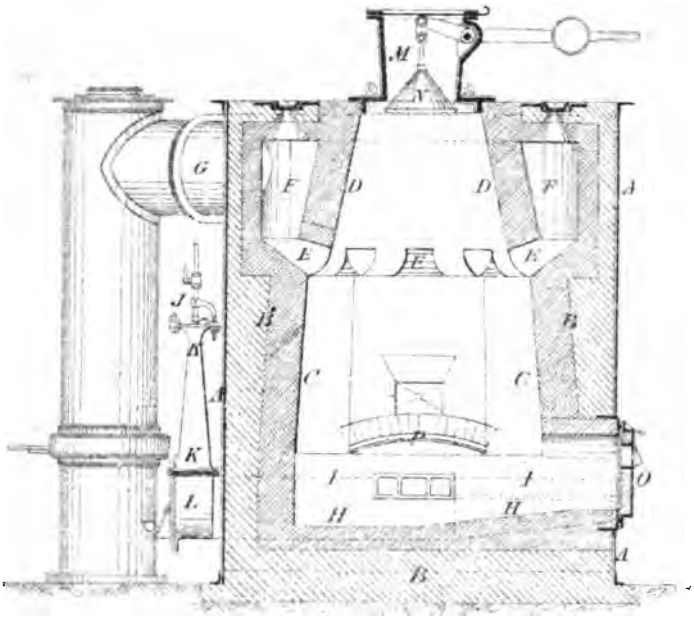
difference of height at which the liquid stands in the two glass tubes measures the difference of level between the stations at which they are held. The idea was not a new one altogether, but the writers thought that the instrument, though not of extensive application for surface work, might be usefully applied in mines. Finding, however, that another gentleman had obtained a patent for a similar instrument about the same date, they contented themselves with using it for their own ordinary work, and satisfied themselves as to its convenience under the circumstances above stated.

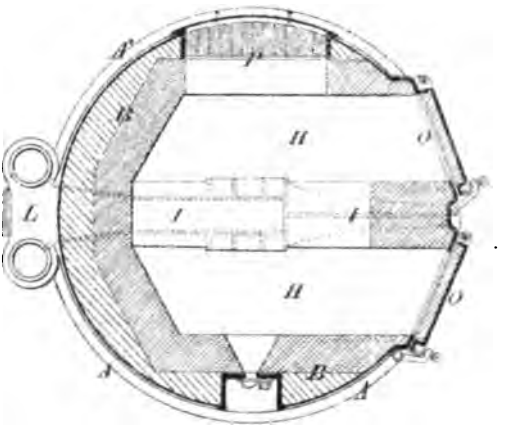
With reference to the use to be made of these levellings, one remark may be offered before concluding. It is very convenient to have the levels of a number of points marked in figures upon the plan of the workings, so that one may obtain at a glance a general idea of the lie of strata. The levels are frequently marked as so many feet above or below the level of the bottom of the shaft. But, although the bottom of the shaft may appear a very good starting point, the use of positive and negative levels is confusing; and when there are two or more shafts connected with the same area, each of which is used as a separate starting or datum—a case which very often occurs—the comparison of the levels belonging to one series with the levels belonging to another is a constant source of small calculations. It is much better to take say 1000 feet below the sea level as the datum, or, if the workings are deeper than that, say 2000 or 3000 feet below the sea level. In this way all the levels may be rendered positive and directly comparable with one another. The levels in one seam will also be comparable with those in other seams and with the contour lines and detached levels which indicate the configuration of the surface of the ground, and which are recorded upon the ordnance plans. In order to reduce all the levels to such datum, it is only necessary to make a levelling from the nearest ordnance bench mark to the shaft. The height of the bench mark above the sea level may be found from an ordnance plan of the district, and from this we may infer the height of the top of the shaft above the sea level. To the height thus obtained add 1000, 2000, or 3000 feet as the case may be, and deduct the depth of the shaft

in feet. The result will be the height of the bottom of the shaft above the new datum, and from this point levellings referred to the same datum may be extended throughout the workings in all directions. A plan figured with levellings in this way acquires a new significance, being practically as good as a model, and is a great help in enabling the engineer to decide many points, more especially with reference to the drainage of the workings and underground haulage.

To illustrate Mr F. J. ROWAN'S Paper on

GAS FIRING.





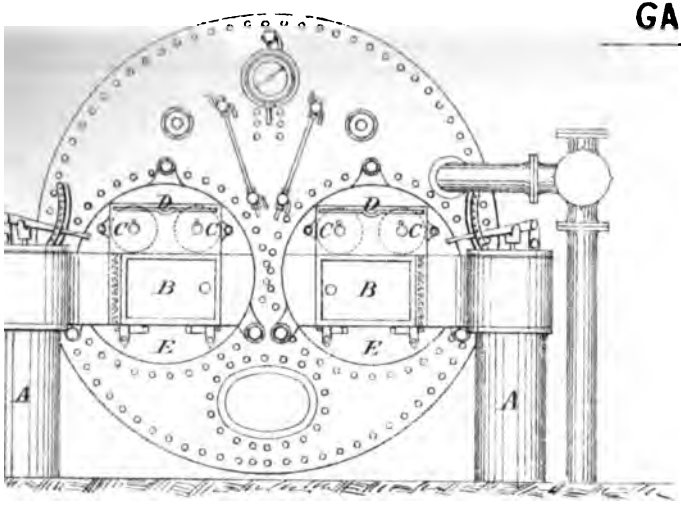
THE WILSON GAS PRODUCER.

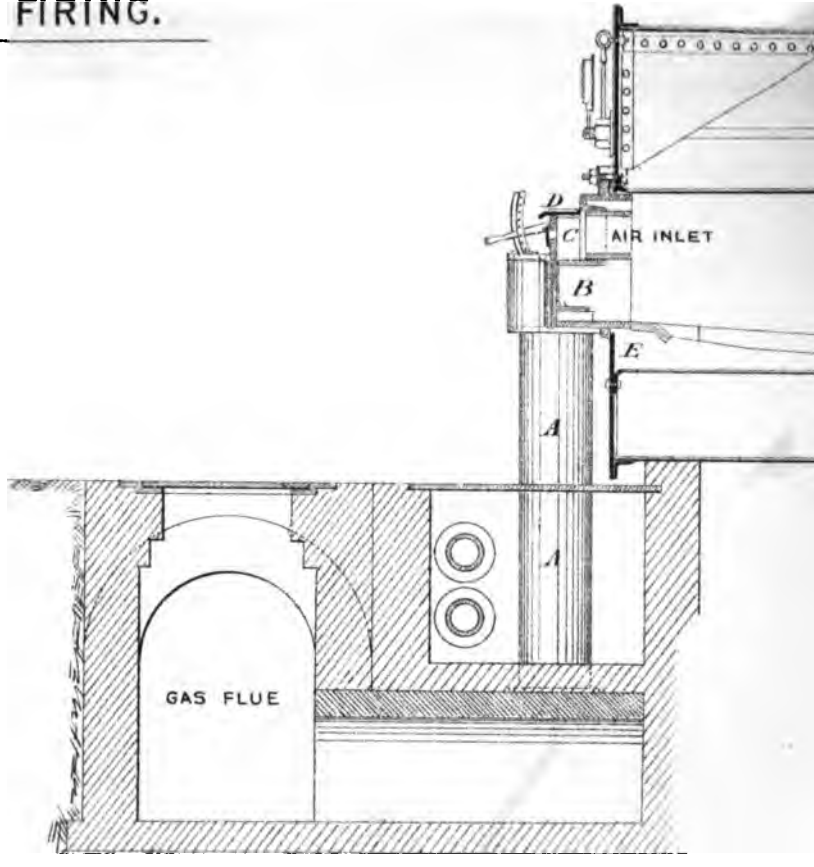
TO BURN 4 CWT. SMALL COAL PER HOUR.

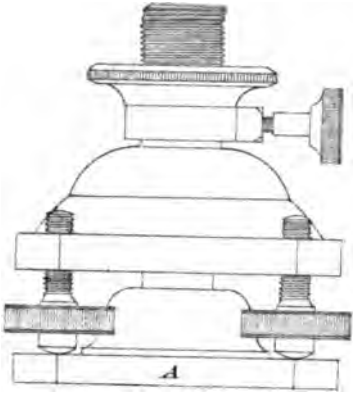
To illustrate Mr F. J. ROWAN'S Paper on

GAS FIRING.

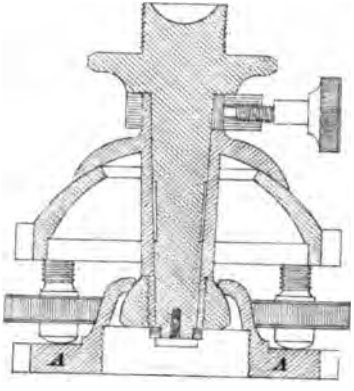
PLATE XVI
M. I. S







Elevation.



Section.

DISCUSSION ON MR GALLOWAY'S PAPER ON "MINING SURVEYS."

The PRESIDENT—I see around me a number of gentlemen very well qualified to discuss this paper. The necessity for care in underground surveying cannot be too strongly insisted upon. There is so much attraction now that we are in the habit of using malleable-iron rails. Mr Galloway's mode of having three sets of legs is an additional check to prevent change of position, and particularly the quick way in which he is enabled to adjust the instrument. With regard to levels mentioned by Mr Galloway, they are very useful. Mr MacCreath, who is here and who is engineer for the Duke of Hamilton, has put them on the Hamilton plans for many years. Mr Dixon does the same; and most of the engineers in Glasgow have begun to adopt that system. It is an invaluable advantage; plans present a new significance when you have the lines and levels, and I cannot too much impress on all of you gentlemen the necessity for adopting the practice. I only wish further to notice that most ingenious instrument for levelling. It is a thing so simple, I wonder it was not thought of long before.

Mr GALLOWAY—In levelling with it you can go over falls and round corners or anywhere. The liquid will not run out even if the india-rubber tube should be raised higher than the top of the glass tubes. That point was discussed at the North of England Institute meeting; we put it to the practical test. The two legs of the syphon are equal, and the liquid does not run out.

Mr HOGG—Might I ask if the tubes would require to be longer if the dip and rise were great, or if it is always a short tube that is used. For instance, if the rise was 1 in 3, what length of tube would be required to level 30 feet?

Mr GALLOWAY—The longer the glass tubes are the better. The length is only limited by the thickness of the seam. We were working mostly in thin seams, and our tubes were mostly 3 feet. If you had longer tubes you would get through more quickly.

The PRESIDENT—Yes, and you would have to be satisfied with less than 30 feet lengths if the dip was 1 in 3. It is only mentioned as a length you can conveniently work with.

Mr GALLOWAY—That is so.

Mr BEGG.—There is one thing I would like to enquire about those levelling staff tubes which Mr Galloway has mentioned. I suppose it is really only half the length of the tube which is available in the levelling.

Mr GALLOWAY—Suppose you had two 3-feet tubes each half-full. If you raise one 3 feet, the liquid will fall 18 inches in it, and rise 18 inches in the other. It is not safe to go to the full 3 feet, but you could go to 2 feet 10 inches.

Mr BEGG—Then your zero was at the top or bottom?

Mr GALLOWAY—At the bottom.

Mr BEGG—I see now, I took it as at the middle. In reference to the three tripods used for the survey, do you claim any particular advantage from that, for it is very seldom attempted here?

Mr GALLOWAY—There is one advantage that you have not with the plumb and lines. In the latter case, I have always found men are apt to hold the lines unsteady, whereas, when you have a stationary object to look to, no error can arise from the carelessness of an attendant; and when the compass is moved forward you can depend upon being able to get the identical spot at which the light was placed for the last foresight. In traversing this is of importance, as one small error of position would vitiate the entire survey. In using only one stand, there is also a risk of your attendant placing a light for a foresight in a position where it is not possible to set up the compass,—a contingency which is not likely to arise when three stands are used. I generally survey with candles standing right up.

Mr BEGG—In our style of surveying here, unless for exceptionally accurate work, we find the usual system correct enough, having the lamps setting out the lines sitting on the pavement and levelling the instrument above them. I have read of this system of three tripods as used in levelling, but with me one great objection to that system appeared insurmountable. You have a given height for the legs to start with, and take it for granted that that height would continue all through. That could

not be the case, and the very exact calculations to be made for each sight demand time and care that are quite unnecessary, so I did not pay much attention to it, and I fail to see much advantage in it except in the instance mentioned where the man gave you a light where the instrument could not be set up. That has often occurred much to the vexation of every one, I believe, and could not occur if you set up the legs of the instrument instead of the light. Of course, if we fall in with this system our lamps would require to be altered and kept plumb in the centre of the instrument and tripod stand.

The PRESIDENT—That would be a small thing,—to have the light rising from the centre.

Mr R. T. MOORE—Mr Galloway has made mention of one or two methods, but I have heard of some methods in which the magnetic needle is not used at all. One is by putting piano-forte wires down the shaft, and in this way a base line may be fixed on without the magnetic needle. I do not know if it would be more satisfactory than the present instrument. I think in general practice the magnetic needle will be found to give quite satisfactory results in underground surveys. Suppose you could read an ordinary compass to a quarter of a degree, then it is very unlikely you would read a quarter of a degree wrong at the same side all through. You might get an aircourse where no rails are and not much attraction by which you could get the true bearing fixed very carefully.

Mr GALLOWAY—I quite agree with what Mr Moore has said with reference to the use of the magnetic needle for connecting a surface survey with an underground survey. The method in which two plumb lines are suspended in a shaft is used in driving railway tunnels, but for long distances, such as occur in mines, and with such long plumb lines as would generally be required, I think the risk of errors would be considerable; at least I do not know any instance in which that method has been practised in mines to any extent. The other method is practised in Durham by at least one gentleman who is very fully employed there in important work, and he certainly has made "holings" by that method to a great degree of accuracy; but I think the method requires an extraordinary amount of care and perseverance.

The PRESIDENT—Mr Galloway referred to the fixing of the magnetic meridian. It has always struck me that the best way of fixing the magnetic meridian was a survey made by a compass on the surface so as not to depend on the variation of the magnetic at all; but simply when you make a survey of any length to have two or three well defined points made on the plan so as to mark the relative positions of the survey with the surface. I have heard it stated the magnetic meridian survey is not correct. A survey made years ago is not correct now, because of the difference of the magnet. That has nothing whatever to do with it. The survey will be done from the meridian at the time and any points fixed on the surface will be there whether ten or fifty years after this. It is the position of the surface as compared with the underground survey you make, and if you put in points, as always ought to be, the variation of the magnet is a very small business, because none of the gentlemen who make surveys, who are present here, ever think of trusting to a meridian ten years old. They take new observations for their survey.

Mr R. T. MOORE—Mr Galloway said plumb lines would be rather inaccurate. By putting them in water or oil at the bottom they would be very steady, and you would have a base line of the extreme size of the pit, say 14 or 16 feet.

Mr GALLOWAY—You would rarely have 16 feet clear on account of timber and obstruction in the shaft.

Mr GARDINER—I consider the best and most accurate, as well as practical method is to have two definite points on surface plan, whereby the underground surveys can be applied to. That can be got by having two pits; the relationship of these accurately fixed, and these in the same manner on a plan. Once done will serve for a lone time for applying underground surveys as well as checking magnetics. This is regularly practised in Edinburgh and Glasgow. In all cases the distance between any two pits are greater than the diameter of any single pit hitherto put down in this country. The plumets can be brought to rest by allowing them to dip into a bucket of water. For general practice a mid-wall slide will be found to be nearly correct.

The PRESIDENT—In Messrs MacCreath's office they have a very satisfactory mode of recording angles in a survey which may not

be known to the most of you, thus:—Suppose a bearing to be 35¼° fully, it is marked 35° +, if a little less than 35¼° it is marked 35¼° −. It may not often be necessary but still I think it is a good thing for surveyors to get into the habit of recording accurately.

Mr HOGG—I would like to ask if in using the tube for levelling the two tubes are half full?

Mr GALLOWAY—Yes.

Mr HOGG—That is to say, you can only level 18 inches with the 3 feet tube.

Mr GALLOWAY—I have often levelled 3 feet. Suppose you lift the instrument 3 feet—the one tube is empty and the other full—the one goes down 18 inches and the other rises, and that makes the 3 feet.

Mr BARROWMAN—With reference to the system of surveying with three tripods, I think the benefit is unquestionable. At the same time, to get the full advantage of it I think there ought to be a special lamp constructed to be set on the top of the tripod. It is apparent that if the lamp or candle is not perpendicular you have not got it in its proper position. For a survey with the vernier a pair of stout legs is indispensible. I have found from experience, those used in this district are too slim. As to the method of marking, referred to by the President, I have no other —it is simply marking the angles to every five minutes of the degree. 1° + is a degree and five minutes; or 1¼° − is a degree and ten minutes and so on.

Mr R. T. MOORE—In many cases engineers use the decimal system. They call it a degree or a decimal and a degree, which is shorter than putting a plus. Instead of 35° plus, they might say 35· or 35·4.

Mr DRINNAN—A special light for taking those surveys is not at all necessary—an ordinary Claney lamp serves the purpose very well.

Mr GALLOWAY—I always use the Claney when a safety lamp is necessary. As to the plumb line, of course if that system were carried out very carefully, as Mr Begg has been saying, it might be done quite as correctly as with the three tripods; but it necessitates great care in having the plumb line over the light.

Mr BARROWMAN—The use of the three tripods makes you more independent of the man accompanying you. I know from experience it is only a few workmen you can rely on to hold a plumb line. It is desirable that the surveyor should be as independent of the men belonging to the colliery as possible. They are not necessarily interested in the correctness of the survey.

Mr HOGG—I was just wondering in looking at the movable sights if there is a scale on the compass so that, if depressed at one end, and looking through the sights, you could read the angle of the dip and rise.

Mr GALLOWAY—When the compass is set level this arc ought to read zero, and when you raise or depress the compass the arc turns and shews the angle.

The discussion was then adjourned.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 10th NOV., 1881,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

RALPH MOORE, Esq., President, in the Chair.

The Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for and admitted as Ordinary Members :—

Principal A. JAMIESON, College of Science and Arts, Glasgow.
ARCHIBALD GRAY, C. & M. Engineer, Stanley Bank, Dalry.
PETER BROWN, Manager, Darngavil Colliery, Airdrie.
Mr WILSON, Manager, East Plean Colliery, Bannockburn.
ROBERT WALKER, Oversman, Tannochside, Uddingston.

THE STEAM INDICATOR.

BY J. M. RONALDSON.

AT the last meeting of the Institute, the statement was made by our President that at collieries the consumption of fuel per horse power per hour may be taken at 15 lbs. Few, in the writer's opinion, will venture to challenge this statement. When steam engines employed by those who have to pay large sums annually for fuel can be made to work with a consumption of 2 lbs. of

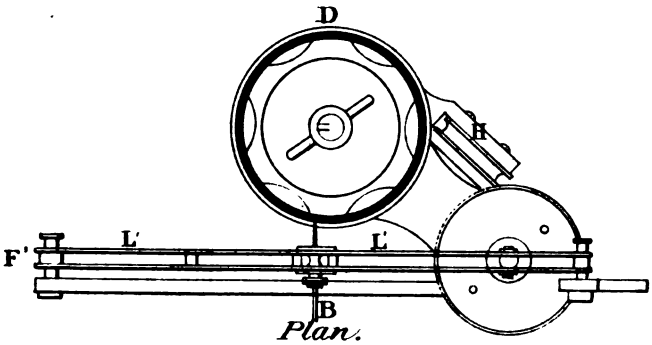
coal per horse per hour, the question might well be asked—Why are mine owners so wasteful in regard to the use of coal? The cheapness with which fuel can be obtained, and the frequent difficulty of getting rid of small coal, doubtless tend to the comparative prodigality in the use of steam which obtains at many collieries; but the fact nevertheless remains that the waste of fuel by the colliery owner is a loss to him, and, it may be added, to the country, which cannot be made up again.

From personal observations made by the writer in various mining localities in Scotland, he has been led to believe that the practice of having the engines in use at collieries and other mines periodically indicated has not hitherto received the attention the subject deserves, and he therefore ventures to bring before the notice of the Institute the use and applications of the steam engine indicator.

The indicator is an instrument which graphically presents to the eye in a diagram the steam pressure in the engine cylinder at every part of the stroke, and an inspection of the diagram produced can at once inform those familiar with the subject whether or not the steam in the cylinder is performing its duty properly. There are various kinds of indicators, which are mostly the same in principle, though varying in details. Richard's indicator, which is shewn in Plate XXIV., is one much in use. It consists of a brass cylinder C, in which the piston P works. The under side of the piston is connected to either end of the engine cylinder—the steam being admitted or shut off at will by a suitable stop-cock, to which the indicator is screwed. The top side of the indicator piston, which is open to the atmosphere, has fixed to it the one end of the spiral spring S, which is compressed when the steam in the cylinder is above, and elongated when the steam is below the atmospheric pressure. The piston rod is joined by means of a short connecting link to the lever L, which works on the fixed centre F, and is joined by the connecting link A to the other lever L^1 of equal length to L and working on the fixed centre F^1. In the middle of the connecting link A is fixed a pencil B, which draws a straight line on a sheet of paper coiled round the oscillating drum D upon any movement of the piston P, this line being parallel to the piston rod. The

To illustrate Mr. J. M. RONALDSON'S Paper on

THE STEAM INDICATOR.



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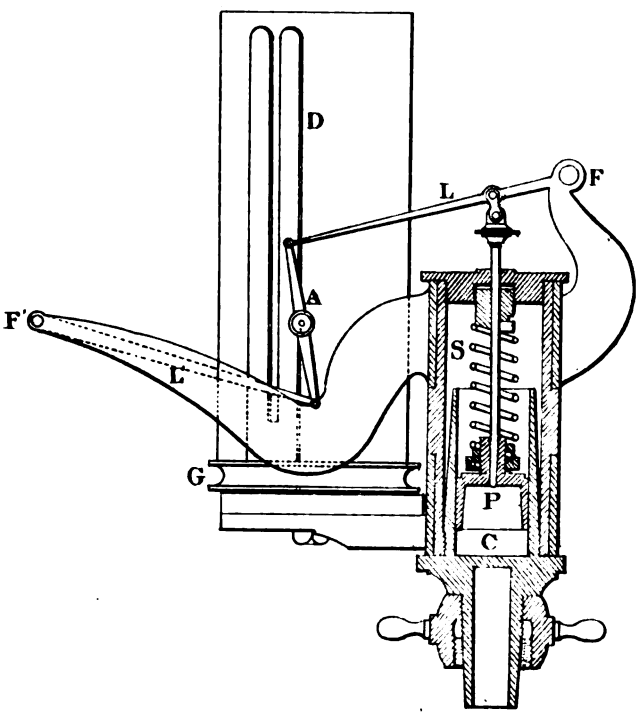

Section.

piston rod is connected to the lever L at a point about one-fourth of its (the lever's) length from the fixed centre F, so that the point of the pencil travels about four times the distance the piston does ; the object of this being to give the piston a comparatively short stroke for a given pressure, in order to avoid as much as possible vibrations of the piston due to its momentum on steam being suddenly admitted or taken from beneath it. The drum D oscillates on its axis, while a cord fixed to D runs in the groove G and round the guiding pulley H, and is attached to the moving parts of the engine by some suitable connection. When connected, the cord turns the oscillating drum in one direction during one-half of the engine stroke and at the same time compresses a spring inside the drum, and this spring turns the drum in the opposite direction during the return half of the stroke. To give a correct diagram, the travel of the oscillating drum D must be exactly proportional to the travel of the engine piston, the engine piston travelling over each fractional part of its stroke, while the paper on the drum travels over the corresponding fractional part of its stroke. Thus, if the length of engine stroke be 4 feet, and the travel of the paper 4 inches, when the piston has advanced from the beginning of its stroke—

1 foot,	the paper should	have travelled	1 inch.
2 „	„	„	2 „
3 „	„	„	3 „
4 „	„	„	4 „

Each end of the engine cylinder having been tapped with a suitable hole, and this being fitted with a stop-cock, the indicator is fixed to one of the stop-cocks, and the cord being connected with the moving parts of the engine so as to give the oscillating drum the required travel, everything is ready. The paper used is specially prepared for the purpose, and the pencil consists of a piece of pointed brass wire which leaves a well defined and permanent mark on the paper. Before admitting the steam by opening the stop-cock, by a stroke or two of the engine the pencil point is made to mark on the paper a line A B (Plate XXVI., fig. 1). This line is termed the " Atmospheric Line," being a line corresponding to the position of the indicator piston when the pressure both above and below

it is the same, and its length corresponds to the length of the engine piston stroke. Suppose the indicator is connected to the bottom end of the cylinder, and steam is admitted at the beginning of the stroke when the steam port is opening, the pencil point will then be at the point A. The indicator piston is forced up to a height where the resistance of the spring equals the steam pressure in the cylinder, and the pencil traces on the paper the line A C. As the engine piston advances the drum revolves, and the pencil marks the line C D. When the engine piston reaches the part of its forward stroke corresponding to the point D, the steam port at the bottom of the cylinder closes, and the steam works expansively to the end of the stroke at E, the curve D E representing the diminution of pressure during the expansion. At E, the end of the stroke, the exhaust port opens, and the steam escaping into the atmosphere, the pencil traces the line E F. Here the pencil should have fallen to the atmospheric line, but owing to the back pressure in the cylinder during the return stroke it draws the line F G. At the point G, before the end of the return stroke is reached, owing to the slide valve closing the connection between the steam port and the exhaust, the steam is compressed and a rise of pressure is the result until upon reaching H, the end of the return stroke, steam is again admitted to the cylinder by the opening of the port, and the pencil is forced up to C. As the indicator spring is so adjusted as to record on the diagram for equal changes of pressure equal vertical distances, a measurement of the area of the diagram measures the work done by the steam in the cylinder. A common scale is for the pencil to record a rise or fall of 1-30th of an inch for every increase or diminution of pressure of 1lb. per square inch. The above dia gram in Fig. 1 is taken off a non-condensing horizontal engine with a 15 inch cylinder and 30 inch stroke—the scale being 30lbs. to the inch. Upon measurement, it is found that steam is admitted to the cylinder at a pressure of 35½lbs. which pressure is maintained until the point D is reached, and that just before reaching the end of the stroke at E, the pressure has fallen to 23lbs; the back pressure, shewn by the distance of the line F G above the atmospheric line, varying from 1½ to ½lb.

It is necessary in order to get a correct indication of the work

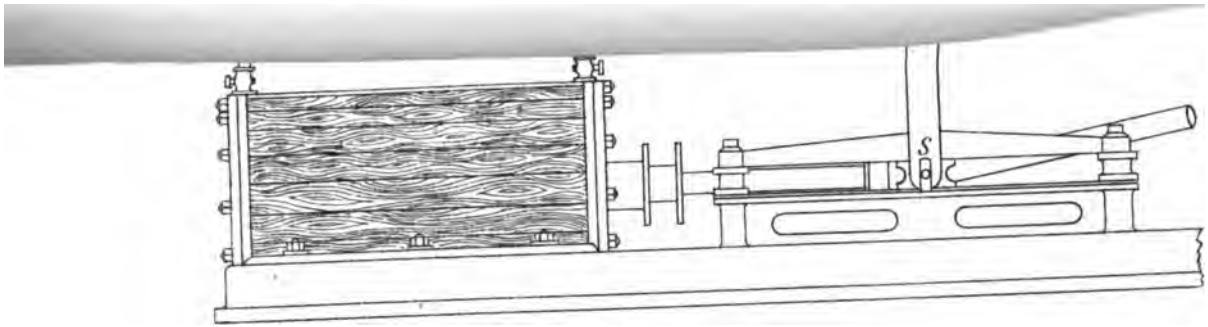
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FIG. 4.

FIG. 4.

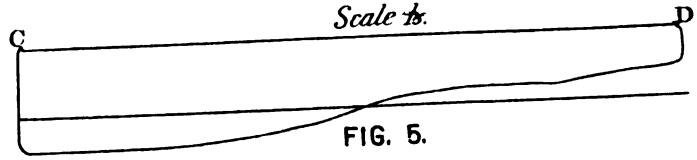


FIG. 5.

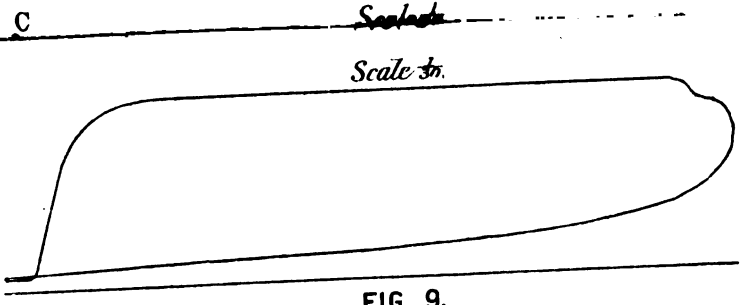


FIG. 9.

done by an engine to take a diagram off both ends of the cylinder, as, frequently, owing to the differences in the setting of the valves and other causes, a very different result is obtained from one end as compared with the result obtained from the other.

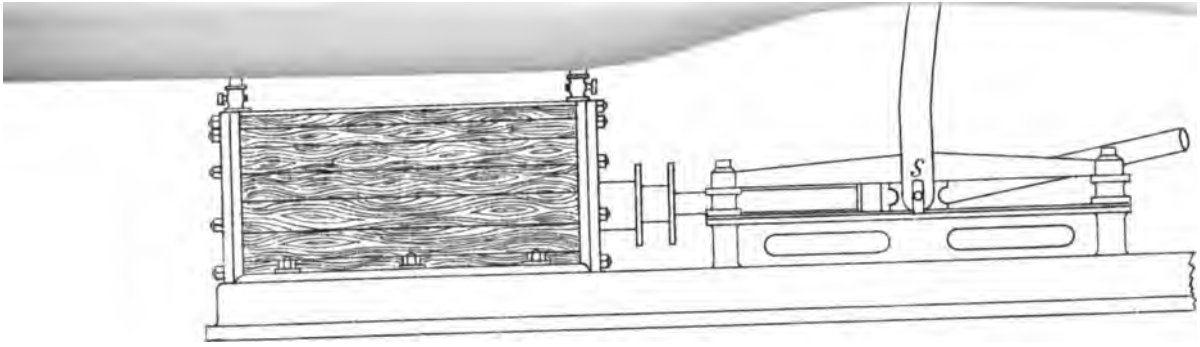
The diagram shewn in Fig. 2 (Plate XXVI.) was taken from the bottom end of the steam cylinder of a Robertson's valveless condensing steam pump, the steam cylinder being 12in. in diameter. The steam exhausted into the water cylinder, which acted as a condenser. A B is the atmospheric line. Steam is admitted at the beginning of the stroke at A, the pressure rising to C. Steam is cut off at D, and, expanding down to E, it exhausts into the condenser where the pressure falls below that of the atmosphere, B F representing the amount of vacuum. The amount of vacuum is increased towards the latter half of the return stroke, when, on reaching G, the exhaust closes, steam is admitted, and the same cycle of operations is repeated. The scale in this case is 15lbs. to the inch, and upon measurement it will be seen that the vacuum is very poor—from the atmospheric line to F being $2\frac{1}{2}$ lbs., and to G 5 lbs.

For making the connection for driving the indicator drum, the radius bars of a beam engine form a convenient medium of attachment. In horizontal engines, a common method is to erect a temporary wooden radius bar of sufficient stiffness, with a slot at one end in which any convenient part of the crosshead works, while the other end oscillates upon a fixed centre placed perpendicular to the crosshead when at the middle of the stroke. Plate XXV. shews such an arrangement, where *b* is the temporary radius bar, *f* the fixed centre, and *s* the slot. The cord *c* is fastened to the radius bar at a point *d* depending upon the relative lengths of stroke of the engine and the indicator drum, and should be taken round a pulley *p* set at such a level as that *p d f* forms a right angle when the piston is at half-stroke. If the cord be taken from *d* to the indicator, as shewn by the dotted line *l* instead of being first taken round the pulley *p*, a distorted diagram is the result, the distortion being the greater in proportion as the angle *p d l* increases. The method of connecting the indicator drum with the moving parts of the engine shewn in Plate XXV. is not strictly correct, but if care be taken to have the temporary

radius bar at least three times the length of the engine piston stroke, and to have the cord between *d* and *p* parallel to the piston rod, for most practical purposes the diagram will be sufficiently accurate. Another method of connection is to have two light pulleys fixed on the same axis, the relative diameters of these pulleys being proportional to the relative lengths of the engine piston stroke, and the travel of the indicator drum. A stout cord has one end attached to the crosshead and the other to the groove of the larger pulley, while another cord similarly connecting the smaller pulley to the indicator drum completes the arrangement. As in the previously described method, it is necessary to lead the cord from the crosshead in a line parallel to the piston rod.

To shew the necessity for having the space travelled by the paper on the drum proportional throughout the whole stroke to the space travelled by the engine piston, the diagrams in Figs. 1, 2, 3, and 4 (Plate XXVII.) are given. They are taken from the engine driving a 40 ft. Guibal fan, the cylinder being 30 in. diameter with 2 ft. 6 in. stroke, and going at 36 revolutions per minute. When these diagrams were about to be taken, it was found that the lower end of the temporary radius bar *b* (Plate XXV.) previously used was fixed to the crosshead, and that the slot cut in the upper end of the bar worked on the fixed centre *f*. The cord was also taken to the indicator without being passed round the pulley *p*. The compound motion thus imparted to the indicator drum produced the diagrams in Figs. 1 and 2. By means of an expansion slide valve the steam was cut off at ·4 of the stroke. Fig 1, however, taken from the back end of the cylinder, shews steam to be cut off at A, which is almost ·5 of the stroke, while in Fig 2, the diagram taken from the front end, the point of cut off is shewn at A, about ·25 of the stroke. The method of attachment was then altered to that shewn in Plate XXV., and the result was the diagrams given in Figs 3 and 4, where A, the point of cut off, is correctly given in each case at ·4 of the stroke.

The average piston pressure is got by dividing the atmospheric line into a number of equal parts—generally 10—and by measuring with a scale across the diagram in the centre of each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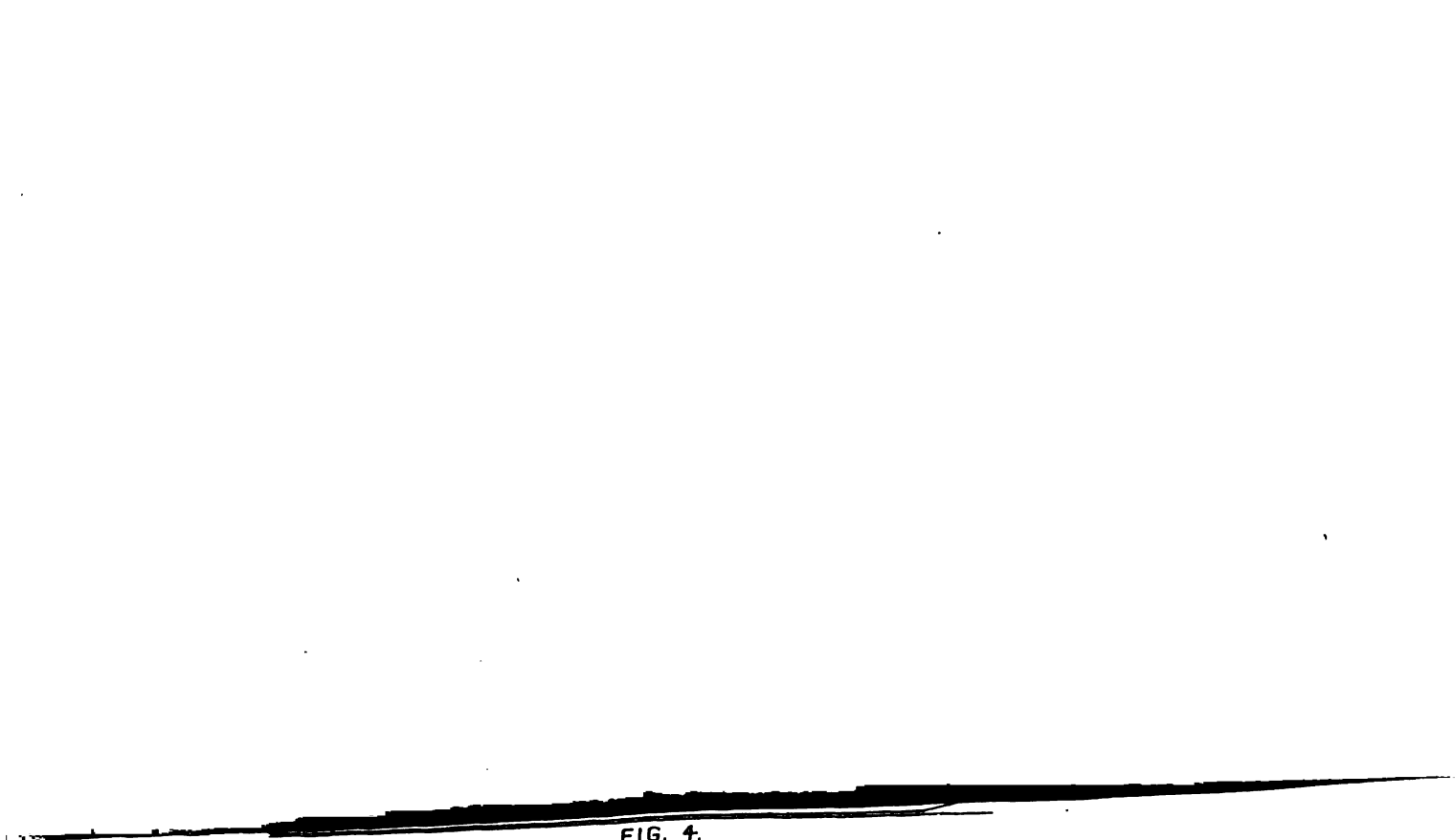

FIG. 4.

FIG. 4.

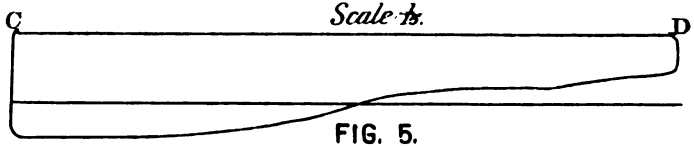

FIG. 5.

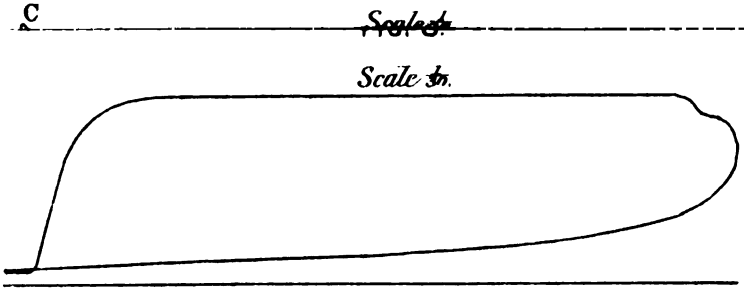

FIG. 9.

division, and at right angles to the atmospheric line. The sum of the pressures thus obtained, divided by 10, gives the average pressure. It may be necessary in cases where the diagram is very irregular in form to divide it into even more than 10 equal parts in order to arrive at a correct average pressure. In Fig. 3 the average pressure is found to be 17·5 lbs. per square inch, and in Fig. 4, 17·5 lbs. The mean piston pressure throughout the whole stroke is therefore $(\frac{17{\cdot}5+17{\cdot}5}{2}) = 17{\cdot}5$ lbs., the piston pressure being in this instance exactly the same on both sides. In Figs. 1 and 2, the diagrams would lead one to believe that the pressures were respectively 19·3 and 12·95 lbs., or a mean pressure of 16·12 lbs. Having got the average pressure, the indicated horse power is arrived at in the usual way, viz.,

$$\text{HP.} \quad \frac{\text{piston pressure in lbs. per in.} \times \text{area of piston in ins.} \times \text{piston speed in ft. per minute}}{33{,}000}$$

By means of the diagrams given in Figs. 3 and 4, the indicated horse-power is therefore found to be $\frac{17{\cdot}5 \times 701 \times 180}{33{,}000} = 66{\cdot}9$. About 6 square inches is deducted from the piston area for the area of the piston rod. The height of the water guage was 1·5 inches, and the quantity of air discharged by the fan said to be 160,000 feet per minute. By applying the formula for obtaining the horse-power of the ventilation—viz., $\frac{\text{quantity of air per minute} \times 5{\cdot}2 \times \text{height of water guage}}{33{,}000} = \text{HP.}$ we find in this instance $\frac{160{,}000 \times 5{\cdot}2 \times 1{\cdot}5}{33{,}000} = 37{\cdot}8$ HP. to be the duty done by the fan. The proportion of power utilised by this fan according to the above data is 56·5 per cent.

The diagrams shewn in Figs. 5 and 6, Plate XXVII., were taken from this same fan engine with the expansion valve set to cut off at about ·7 of the stroke, the stop valve being adjusted so as to make the fan run at 36 revolutions per minute—the same speed as before. The average piston pressure is 15·4 lbs in the former, and 17·85 lbs. in the latter diagram, the mean of the two being 16·62 lbs., which is less by ·88 lbs. than the mean pressure given in the diagrams shewn in Figs. 3 and 4. With this pressure the indicated HP. exerted by the engine is shewn to be 63·5, and the proportion of power utilised by the fan to be 59·5 per cent. This latter result coincides closely with the result obtained by diagrams taken from the twin engine used for driving this same

fan at a speed of 30 revolutions per minute. The HP. of the engine was 42·2, and the quantity of air was stated to be 140,000 feet with 1·16 inch of a water guage. Here the proportion of power utilised by the fan was 59·9 per cent.

A comparison of the diagrams given in Figs. 3 and 4, with those given in Figs. 5 and 6, illustrates the economy to be obtained by working steam expansively. By measuring the combined areas A B C D in the former, and comparing them with the combined areas A D E F, it will be found that they are as 235 is to 116; while in Figs. 5 and 6 the combined areas shewn by the same letters are as 276 is to 57. As the areas A D E F represent the proportion of work performed by the steam working expansively, it therefore follows that in Figs. 3 and 4, where the cut off is at ·4 of the stroke, the proportion of work performed by the steam during expansion is 33 per cent. of the whole, as compared with only 17 per cent. in Figs. 5 and 6 where the steam is cut off at ·7 of the stroke.

It is seen from these diagrams taken from the 40 feet fan engine that the initial pressure is not sustained until the point of cut off, there being a considerable diminution of pressure from B to A. This shews that the steam is not able to follow up the piston with sufficient rapidity. Such a decrease of pressure may be occasioned by the ports or the steam pipes being too small, or by the steam being wire-drawn in passing through the stop valve. In this instance, the reduction of pressure was due to the action of the stop valve which was only partially open, as the engine was capable of doing much more work than it was required to perform.

The diagrams shewn in Figs. 3 and 4 (Plate XXVI.), are taken from the bottom and top of a non-condensing beam pumping engine while disconnected from the pumps and running at 20 strokes per minute. That the slide valve was not properly adjusted is apparent. In the diagram shewn in Fig. 3, taken from the bottom of the cylinder, steam, instead of being admitted at the beginning of the stroke at A, is only admitted after the piston has travelled $\frac{1}{11}$ of its stroke at a point corresponding with B. The exhaust port being also closed by the slide valve, a vacuum is formed behind the piston before the admission of

steam. At C, the end of the stroke, the exhaust port is also too late in opening. The same faults, though to a less extent, are shewn in Fig. 4, taken from the top of the cylinder.

The diagrams given in Figs. 5 and 6 (Plate XXVI.), were taken from one of Tangye's special steam pumps, the steam and water cylinders being respectively 12in. and 6in. diameter, with a 2ft. stroke, and water was being pumped up a dook a vertical height of about 30ft. To get rid of the discharged steam, the exhaust pipe was led into the suction pipe. The result of this was that with a piston speed of 64ft. per minute (the ordinary rate of working), a slight vacuum was obtained during the latter half of the return stroke, as shown in Fig. 5. The diagram in Fig. 6 was taken with a piston speed of 144ft. per minute. At this speed, the back pressure indicated by the height of the line AB above the atmospheric line was excessive, shewing that the getting rid of the exhaust steam was effected by a great waste of fuel when anything beyond a moderate speed was attempted. As might be expected in this class of engine, the steam pressure has to be maintained from the beginning of the stroke C to the end at D.

A horizontal engine with 15in. cylinder and 2ft. 6in. stroke, and going at 60 strokes per minute, was suspected of being in bad working order, and was indicated. The result was the diagram, taken from the back end of the cylinder shewn in Fig. 7 (Plate XXVI). The diagram taken from the front end was equally bad. It was found that the slide valve face was passing a great deal of steam, owing to a number of channels being worn in the metal, and this the diagram revealed by shewing an unusual amount of back pressure during the middle of the return stroke. After the engine was overhauled, the indicator was again applied, and produced the diagram in Fig. 8, which is much more satisfactory. Owing to the action of the governor, the steam is shown to be wire-drawn between the beginning of the stroke A and the point of cut-off at B. The diagram in Fig. 1 was recently taken from the same engine.

In Fig. 9 is shown a diagram taken from the top end of a beam winding engine exhausting into a feed-water heater. This is another example of imperfect valve setting and too much back pressure.

The engine used at Earnock Colliery for driving the dynamo which produces the electric light has a cylinder 11¼ dia. × 16in. stroke, and runs at a speed of 76 revolutions per minute. The diagrams shewn in Plate XXVIII. were taken from this engine. Figs. 1 and 2 are "friction diagrams," *i.e.*, diagrams taken with the brushes off the dynamo to ascertain the power absorbed by friction in the engine and belting alone. The steam expands until the pressure comes below that of the atmosphere, thus effecting a retarding influence upon the piston towards the end of the forward stroke, while towards the end of the return stroke, the compression due to the closing of the exhaust causes the back pressure, shewn in the diagram in Fig. 1, taken from the back-end of the cylinder, to rise above the line of steam pressure during the forward stroke. In Fig. 2, taken from the front end of the cylinder, the line of back pressure due to compression almost touches the line of steam pressure. It will be readily understood that where these two lines cross one another, the area inscribed between them requires to be deducted from the area of the diagram in calculating the average pressure. In Fig. 1 the average pressure is 1·95lbs., and in Fig. 2 it is 2·85lbs., which gives a mean of 2·4lbs., and the HP. = 1·45. The diagrams in Figs. 3 and 4 were taken with the brushes on, and the Swan lamps lighted, and the HP. given by the engine is 6·5, which shows that it takes 5·05 HP. to produce the electric light alone. Fig. 5 was taken from the front end of the cylinder when the engine was starting, and before the action of the governor caused the wire drawing shewn in the other diagrams.

In Plate XXIX. (Figs 1 and 2) are given diagrams taken from a 12in. × 12in. engine, going at 110 strokes per minute, and driving a 5½ft. Schiele fan. In this engine the indicated HP. is 19·4.

Diagrams taken from a Corliss engine are given (Plate XXIX.), Figs. 3 and 4.

Some indicators have an arrangement whereby a roll of paper is coiled up inside the drum, and by a ratchet motion a fresh surface of paper can be presented to the pencil at every stroke of the engine. Such a continuous diagram is shown in Plate XXIX. (Fig. 5.) It was taken from the front end of one cylinder of a

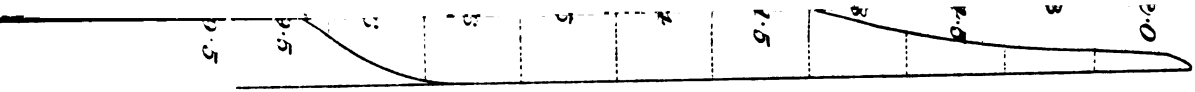

FIG. 4.

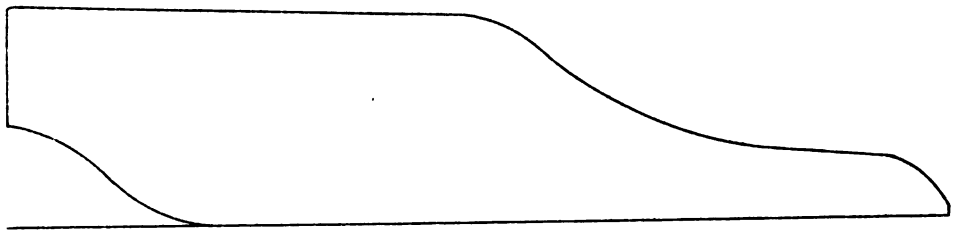

FIG. 5.

coupled winding engine, the cylinders of which are 28in. dia., with a 5ft. stroke, and winding 52cwts. of coal from a depth of 120 fathoms in 27 seconds. The engine started to wind when the pencil was at A. Steam entered the cylinder at B, the pressure rising to C, while steam was admitted almost to the end of stroke at D. During the return stroke the ratchet motion shifted the paper to the left, and steam was admitted for the next stroke at E. As the speed increased so did the back pressure. The steam was shut-off at F as the loaded cage approached the pit-mouth, and the handle of the link motion being levelled so as to close the ports, the action of the piston for several strokes gave the vacuum shown.

In Plate XXX., Figs. 1 and 2, are given diagrams taken from an engine with a cylinder 20″ dia. × 3′ stroke, and driving a 25′ × 8′ Guibal fan at 56 revolutions per minute. An inspection of the diagrams shew that the steam ports are too late in admitting steam, which is considerably wiredrawn before being cut off at about $\frac{3}{4}$ stroke. The water guage was $1\frac{5}{8}$ inches, and the quantity of air said to be 69,080 feet per minute. The HP given out by the engine was 26·75, and the HP in the air 17·7, so that in this case the proportion of power utilised by the fan is 66·4 per cent.

In Plate XXX., the diagram in Fig. 3 was taken from the top, and that in Fig. 4 from the bottom of the cylinder of a condensing beam pumping engine with piston valves. The cylinder is $28\frac{1}{2}$″ dia., with a piston stroke of 6 feet, and the crank made 14 revolutions per minute. The engine is geared to two bell cranks, and from the rods which are attached to the one a $10\frac{1}{2}$″ plunger forces water to the surface from a depth of 63 fathoms, while the other is connected to a lifting set with a $10\frac{1}{2}$″ bucket, raising water also to the surface from a depth of 33 fathoms. Both plunger and bucket have a stroke of 5 feet, and are driven at 7 strokes per minute. The engine, being more heavily burdened, goes slower during one revolution of the crank than the other. The lines A B shew the steam pressure during the revolution when the crank goes slower, and the lines C D the pressure when the engine meets with less resistance. Taking the average, the mean piston pressure is 11·7lbs., and the HP of the engine is 37·704, or

1,244,224 foot pounds per minute. From the foregoing data it is found that the foot pounds of water raised per minute, after deducting 7 per cent for slip, &c., amount to 719,258 ; hence the proportion of work utilised by the pumps is 57·8 per cent. of that given out by the engine.

These examples of the useful effect of fans and pumps are given to illustrate the value of the indicator as a means of ascertaining, in various kinds of machinery driven by steam power, the proportion of work utilised.

In fixing the indicator, several precautions require to be taken. It should not be fixed close to a steam port where the rush of steam past the inlet to the indicator piston gives an erroneous pressure, nor should it be fixed where condensed water is apt to enter. The best place is to have the taps fixed to the cylinder covers, and where that cannot be done readily, care must be taken that the piston at the end of the stroke does not cover the orifice leading to the indicator. Stop-cocks should be of ample size, as well as pipes leading to the indicator from the cylinder, where they are required, and sharp bends ought to be avoided. Such pipes, where used, require to be well covered, and the indicator should be heated up before a diagram is taken. The cord leading from the drum should not stretch. The indicator can be used for other purposes in addition to shewing the work done inside a cylinder. In a case where the steam is wiredrawn, by fixing it to the steam chest of the engine and driving the drum in the usual manner, the diagram thus given tells whether the wiredrawing is due to want of room in the cylinder passages, or to too small a steam pipe. Similarly, by applying it to the exhaust pipe, it reveals where the fault lies when the back pressure is excessive. It can also be applied to pumps to shew the various pressures either in the suction or discharge pipes, and when Mr MacCreath brings before us his paper on air vessels, he will probably produce some interesting facts revealed by its application to this subject.

THE PRESIDENT—The Indicator is of immense use, not only as indicating the pressure during the progress of the piston, but it indicates the state of the machinery by which the steam is admitted into the piston. Then you can tell if your slide valve

is defective, if it is leaking. You can tell also whether your valves are properly set. In the case of the Atlantic steamers, where they work with great exactness, the engines are very carefully indicated, and cards kept so that the parties at the end may see the state the engines have been in during the voyage. It is a very remarkable instrument, and one which requires more attention than what has been bestowed on it by mining people. Mr Rowan, I think I am right as to what I have said in regard to the American liners?

Mr F. J. ROWAN—I cannot speak from personal knowledge as to Trans-Atlantic steamers, but I know that in many trading steamers it is the practice to take at least one set of cards during every engineer's watch to show the state of the engines. Before sitting down, I may be allowed to ask Mr Ronaldson a question: I notice on the Indicator produced a little attachment at the top of the drum which I have not noticed in other indicators. What is its use?

Mr RONALDSON—This is for giving a continuous diagram. You can take a succession of diagrams, and at every stroke of the engine a fresh surface of paper is presented.

Mr ROWAN—May I ask how the papers are coiled on the drum?

Mr RONALDSON—The paper in a loose roll lies in a compartment inside the drum. One end of the roll is drawn out, passed round the drum, and is then taken inside and coiled round a smaller drum, which when required can be turned a little by the ratchet at every stroke of the engine by putting the small wheels at the top of the drum in gear.

Mr ROWAN—How do you obtain separate cards with this indicator; do you move the drum round by hand?

Mr RONALDSON—All you have to do is to let the ratchet work for two or three strokes of the engine until an entirely fresh surface of paper is presented to the pencil.

Mr ROWAN—I saw at the Naval Exhibition in Glasgow one of Richard's Indicators with a different arrangement for pushing up the card at each stroke of the engine. It moved the paper vertically, so as to have the expansion curves one below the other.

Mr RONALDSON—This works horizontally instead.

The PRESIDENT—I look forward to the time when we shall

just take as much care in taking diagrams of our engines as they do in steamers. I know that at Fence, Lesmahagow, they take diagrams regularly.

MR ROWAN'S PAPER.

The PRESIDENT invited further discussion on Mr Rowan's paper.

Mr DIXON—I have nothing further to say except to repeat very much what you (the President) said last evening. We are all connected with collieries, and would like to know how many generators it would take to keep a range of colliery boilers going, and what savings would result? For instance, take ordinary boilers, 30ft. long by 6ft. in diameter, and five or six of these in a range, how many generators would be required.

Mr BEGG—I would just, in addition to what Mr Dixon has said, remind you that Mr Rowan in reading the paper said he might be able to give us figures showing the economy of these heaters, and I would like to know if he is now in a position to do so?

Mr DIXON—There is another point I would like information on, viz., is it necessary, or an advantage to use round dross, or will very small gum do to produce the gas? There are large quantities of gum about collieries for which at present there is little or no use, and which might be utilized in that way. I would also ask whether such would do with a considerable percentage of refuse, say 15 per cent.?

The PRESIDENT—We are a very practical set of people you see, Mr Rowan. We are all apparently pleased with the apparatus, but what is the saving to be effected by it? At the same time, there might be something else than economy, such as —could we do away with smoke?

Mr ROWAN, in answer to Mr Gardiner, said that carbonic acid is decomposed if it is passed over a heated surface without access of air, provided that surface be one of heated carbon. It is not immaterial what heated surface is employed, as few surfaces but

that of red-hot carbon would do. As to the economy of firing boilers, I suppose the question that has been put by Mr Dixon and others, referred to the firing of boilers by gas? I am in the same position with regard to that question as when the paper was read. I am waiting for some experiments which must be carried out in order to get figures, that is to say, to get comparative tests with gas, as against similar boilers fired by hand in the ordinary way. There are several boilers at work with producer gas in England at various works, but it is quite impossible to get the owners of these works to say what their practice is. They like to keep the facts to themselves. I heard only yesterday that one large firm in England, who have been working for three months, experimentally, with one gas producer, are applying to have other three put up for the use of their boilers, and I made an effort to get some information from them without result. However, since your last meeting, a personal friend, who is extending his works, has decided upon applying gas to firing a steam boiler to be erected in it, and as he has a precisely similar boiler fired by hand, I hope that before very long I may have the pleasure of handing in a supplementary note to your society, giving some results of comparative trials. It is of course a great question in applying such an apparatus as the gas producer, what is to be gained by its use. In many operations the gain is enormous. The one I instance in the paper—that of Mr Dunnachie, Glenboig—shows the enormous saving of from 50 to 60 per cent. in fuel besides the saving in time required for the operation of burning his fire-bricks. In some metallurgical operations, such as the welding of iron tubes, when carried out by gas it is found that a saving of about 60 per cent. has been realized, taking into account the difference of quality, as well as quantity, of coal used in the producer from that used in furnaces in the ordinary way. Tube welding, as ordinarily carried out, is a wasteful process as to fuel ; it requires a very good quality, and consumes large quantities of coal, so there is great room for economy. As to colliery boilers, if I had to deal with them alone, I would not have any difficulty in reducing the 15lbs. per horse-power to 4lbs. and 5lbs. ; but, as Mr Ronaldson has shewn us very clearly, there is another factor in this question, *i.e.*, the

engine and the gas producer will not help a bad engine. If engines require to have full steam on for two-thirds of the stroke, and a good deal of the steam is used wastefully, it is quite impossible to predict any saving in fuel, even with great improvement in boiler-firing, so that I am afraid, even were I to give you figures showing the economy attained with an engine working properly, you might be disappointed if you applied the same apparatus to your boilers. The quality of coal used in the producer may be very low indeed. In one work in Belgium, the producers worked successfully with a coal containing 50 per cent. of ash. That is very much worse than anything that can be found in this country. Of course, in using such a coal, the operation of cleaning has to be repeated so much more frequently, because of the accumulation of ash being more rapid. I am prepared to work any of these producers with what Mr Dixon calls "gum." It does not require round dross at all. It is quite possible to have a coal that is too close, especially if it is a coal that cakes very rapidly; but that only means a good deal more work to the men attending to the producer to keep it open, and prevent the cake "vaulting," or forming cavities in which the gas would be burnt, the producer thus being turned into a furnace. With proper attention, coal-gum can be used; in fact, in one work the operation of tube welding was carried out with gas made from "gum."

The PRESIDENT—The "gum," or small coal, does not cake. It is open burning.

Mr ROWAN—In that case it would answer perfectly. This is one point on which we have a decided advantage over the Siemens' producer. I believe that at the Newton Steelworks they find it advisable to use what is called triping, mixed with the dross, in the producers. In our case we use nothing but dross; and Mr Dunnochie's operations are carried out with a very cheap quality.

The PRESIDENT—I should fancy the only difference betwixt the gum and the dross is that in one case the air cannot get through the gum; otherwise it contains as much carbon as the other, although it cannot be burned so readily.

Mr ROWAN—The first operation that takes place when heat is

applied to the coal in the producer is that the volatile hydrocarbons are given off and the coal assumes the form of coke more or less condensed according to quality. The making of it into gas is not rapid, and it is open enough to form carbonic oxide.

The PRESIDENT—It is not open in the slightest. It is, in fact, small dust.

Mr ROWAN—Yes; but not when partially coked.

Mr DIXON—Will the gas in generating pass through it? That is the question. It is a very important question.

The PRESIDENT—Mr Grant, of Bothwell Castle Colliery, is here. He will be able to tell us if they can work with dross in their gas producers at Bothwell Castle.

Mr GRANT—We work Siemens' furnaces with soft coal dross, not with gum.

Mr ROWAN—I know it is necessary with Siemens' producers to have pretty round coal, but we have worked the Wilson Producer with what is equivalent to gum, what in England they call "duff," I believe.

Mr DIXON—I would like to hear of some trial with our gum.

Mr SMART—The best way would be to ask Mr Dunnochie to give it a trial.

The PRESIDENT—Mr Dunnochie's work is quite a different thing. The only thing I understand, Mr Rowan, would be you would have in this case perfect combustion as against imperfect combustion with the ordinary grate.

Mr ROWAN—That is true, but Mr Dunnochie's kilns are fired by gas from this producer.

The PRESIDENT—Precisely, but you would not have the same economy.

Mr ROWAN—Not in firing boilers. Mr Dunnochie requires to use heat regeneration in consequence of the very high temperature which is required for burning his bricks. It is impossible to get such a temperature without regeneration. The temperature you require with boilers is not more than a half of what Mr Dunnochie requires, and it is, therefore, quite possible to attain that with the use of atmospheric air in heating.

Mr DIXON—I think Mr Rowan, if he possibly can, should make

the experiment I suggest, because if he wants to introduce the producer at collieries, the one element in the whole affair, is whether it will work with gum or not.

The PRESIDENT—I expect Mr Rowan would like some of you gentlemen just now to make the experiment; but still I think it is fair to ask Mr Rowan that he should present to us the saving that would lead us to entertain it. If I recollect, Mr Rowan said that he could only burn 4 cwt. of dross per hour. Very well, in a boiler 30 × 6 there is no difficulty of burning 3 tons in twelve hours. Well, then, you would only give us 2 tons 8 cwt. for each furnace at that rate. Then, that to each boiler would imply a very great deal of money. What do you get for it is the question? I think if Mr Rowan could give us any reasonable hope that it would be worth while for anyone to try the producer, I am inclined to think some one would,—other things being equal,—for the sake of avoiding smoke. That is a very important matter for collieries getting near towns. Just now I am safe to say you get a boiler 30 × 6 and everything fitted for £200.

Mr ANDERSON—A good deal less.

The PRESIDENT—Well, suppose you add the cost of a producer to that, you would require to get something for it.

Mr J. B. DALZELL—The important question has arisen amongst us to-night, how to utilize the very smallest of the coal. We have large heaps of this description at our collieries which we cannot use, simply because if it is put upon the fire it chokes combustion. I learned lately that a Scotch gentleman in the United States, owning extensive mills there, has managed to overcome that difficulty. Of his mode, I hope to have some particular accounts shortly, but, meantime, I may say that he gains the desired effect by closing the stock-hole and directing a blast into it.

The PRESIDENT—I think they would. You are just coming on to the original application of Mr Rowan's furnace.

Mr ROWAN—You have fore-stated me. I was about to claim this gentleman's evidence as a reply to you and Mr Dixon. It is in principal just what is done in the producer. That is a closed furnace with a steam blast applied, and I have not the slightest doubt that the chemical action going on in the interior permits

the gases to pass through. I gave in the paper several of the reasons why we believe that firing boilers by means of gas is really worth considering. I can only add to that, figures showing the economy in some given cases. We cannot help seeing that a great deal of coal is wasted, because all that goes away in the shape of smoke is simply thrown away. If that were all burned, you would get a good deal more heating power out of the coal than is obtained at present. I have not the least doubt that a considerable economy would be realised. At a recent meeting of the Institute of Engineers and Shipbuilders I advocated the adoption of gas firing for river steamers for the same reasons as I mentioned in my paper, and several of the engineers thought a good deal of the prospects of such an application.

The PRESIDENT—Mr Rowan, what would be the additional cost to a boiler which cost £200 to fit up?

Mr ROWAN—Only £100, or with royalty, £130.

The PRESIDENT—Why then, there would not be a great loss if it failed. Perhaps, Mr Grant, you will tell us if the Bothwell Castle arrangement takes more fuel. Will you burn as much as with the open firing?

Mr GRANT—No, hardly as much; but the coal is of a better quality.

Mr ANDERSON—There is one of the remarks Mr Rowan made, although not connected with gas-firing, I think deserving of attention. It is the waste of fuel by the opening of the doors letting in air. I do not know whether mechanical stokers come anything near the economy Mr Rowan gets from this system of gas-firing or not. I saw one last week. It was attached to a boiler 30 feet long and 7 feet diameter, double flued. I was told that the saving effected by the operation of it is somewhere about 25 per cent., and the gentleman who has used it said he would have it applied to every one of the boilers that are to be erected in the work, that is to be fitted up within a very short time. These mechanical stokers cost something about £90, but they do away with loss through cooling of the plates and letting in of cold air; and are also effective smoke consumers, because the coal is put in in such a way that the air does not pass through the doors. There is a constant action of the bars, which

keeps everything burning bright, and they can raise far more steam than although two men were employed. It is better than any number of men attending to the furnace, because it is always regular. This is perhaps away from gas-firing, but it is in the lines of economy.

Mr R. T. MOORE—With regard to the relative economy of the mechanical stoker and Wilson's gas producer, one would think there would be an advantage in using the mechanical stoker, as there would not be any loss by radiation in conveying the heated gas from the heater to the furnace. If the coal could be burned perfectly by any system of mechanical stoking, all the heat would be generated in the best possible position for applying it to the boiler, so that perhaps it might be better for us to improve our old system than to adopt the new one of firing by gas.

Mr ROWAN—That might be true, but for the fact you have the mixed cold air with the gas that is coming up from the coal. Now, it is found where producers are placed close to a furnace, almost practically to form part of it, the gas being consequently taken in very hot, that it is almost impossible to get cold air to mix rapidly, whereas if the gas and air are approximating of the same temperature they mix more readily. In working mechanical stokers, there is a hot fire, hot over the grate bars, and the coal is put in in small quantities. First of all, the hydro-carbons are distilled, and cold air rushing in meets them and they are carried some distance along before smoke disappears. Air is admitted through the grate bars to burn the fixed carbon, and the carbonic oxide thus formed needs air to burn it, so that more than is necessary for the hydro-carbons must be admitted above the bars. The loss of conveying the gas from producers to boilers is really not a very great thing, because the gas as it leaves the producer is found to be about 600° Fahr. By cooling down from that the loss would not be very great, especially if the cooling down of the gas a little enables you to get a more perfect mixture of air rapidly and so a more perfect combustion.

Mr BARROWMAN—If Mr Rowan's expectations can be realised in practice at collieries, I have no doubt whatever that his gas producer will be very soon adopted. Under the modern systems of working, with not only the steam engines on the surface for wind-

ing, but also steam engines above or below for haulage, and engines for coal-cutting machinery, and so on, it is remarkable the amount of fuel consumed about a pit-head. Now, the coalmaster not only loses his profit on the fuel so consumed but he is also at the extra expense entailed by the handling of that fuel.

Mr RONALDSON—At the bottom of p. 195, Mr Rowan gives us the quantity of air required for complete combustion into carbonic anhydride, but he does not state how much is required for complete combustion into carbonic oxide. Then again at top of p. 196 he states :—(reads). Is this 1 lb. of gas carbonic oxide alone or does a part consist of the nitrogen of the atmosphere which is taken into the producer?

Mr ROWAN—I merely give these, the proportion of air required for a pound of carbonic oxide gas, to show that by introducing into the furnace carbonic oxide instead of coal, a much less supply of air is required, and therefore there is not so great a strain put upon the chimney draft.

Mr RONALDSON—I understand that. What I want is this :—Is this pure carbonic oxide or carbonic oxide mixed with the nitrogen of the air?

Mr ROWAN—It is pure carbonic oxide. I compare it with pure carbon merely to give a basis of comparison of results with solid and gaseous fuels.

The PRESIDENT—We have now had this subject thoroughly discussed. There is one point very clear to me—viz., that we have learned a good deal by Mr Rowan coming here. We have learned a good deal more of the combustion of coal; and even on that point we are very much obliged to Mr Rowan. But Mr Rowan has read us besides a very carefully prepared paper, and explained the arrangement of Mr Wilson's furnace to us. I do think we have before us something which, as Mr Barrowman says, may enable us to utilize some of the waste coal, which is lost at present both to the coal owner and also to the proprietor of the minerals, which it would be very well to see utilized. I, for my own part, see some use in Mr Wilson's arrangement, and I have no doubt but in a very short time, when the results of the trials which he speaks of are more particularly brought to our notice, that even here some of the parties may be induced to give

the gas producer a trial. I was somehow under the impression that it was much dearer than what it is, but if a boiler with this arrangement only costs a half more, I do not see but it is very well worth a trial. Meanwhile, we are very much obliged to him, and you will, I have no doubt, give him a very hearty vote of thanks.

This having been cordially agreed to,

Mr ROWAN—Allow me to thank you very heartily for so kindly receiving my paper, and especially to thank you, Mr President, for the very kind terms in which you introduced me to the notice of your excellent society.

MR LINDSAY GALLOWAY'S PAPER.

The PRESIDENT intimated that Mr Galloway had not been able to be present, but that the discussion, whatever it might be, would be in print, and would enable him on a succeeding night to reply.

The SECRETARY read the following note from Mr Gardiner :—

Mr GARDINER—At bottom of page 205, "Before one can depend," &c. I have surveyed with a Hedley's dial on lengthened legs, in a road with malleable iron rails, 28lbs. per yard, and found no attraction; height of road, 7ft. Again, on page 206, "For underground work," and so on. I am of the opinion the simplest way, with equally good results and less chance of error, is a system of double bearings, in roads with malleable iron rails, pipes, &c., checking the attraction as often as opportunities are afforded. *Example*—I have seen the system tested under the following conditions :—An ordinary side road in a gas coal working, width 5 feet 3 inches, height 4 feet 6 inches, with cast iron rails, and a column of 6 inch cast iron pipes along one side; length about 13 chains, and took something like 30 to 40 bearings. Five surveys by four different surveyors—two of these were by angles, and *one* by double bearings, the results were the same. Further—In the same paragraph, page 206, "Great speed and ease." By what standard is this speed

measured? If Mr Galloway would state how many bearings per hour, at the same time the system of working and height of seam, it will enable the members to judge by the amount of work done in Scotland. I have seen 35 to 40 bearings per hour for six successive hours in the stoop-and-room workings of Ell and Main Coal in Hamilton and Larkhall districts, and 20 to 25 bearings per hour in the Steam Coal of the Slamannan district, long-wall system, done by our Scotch system of surveying. At bottom of page 207, and top of 208, Mr Galloway describes a method for checking the magnetic variations. In theory it is good, but in practice it is deceptive. Should the system of working be long-wall, before the time of checking the variation comes round the stake would not or should not be depended on. In fact, this is one point in the duties of a Mining Surveyor that is but little attended to, or rather is attended to in but an indifferent manner. I really believe more encroachments have been made and other mistakes of importance by wrong magnetics than by surveying proper.

Mr BARROWMAN—I think Mr Galloway's paper is a good one. It is short, but clear, and although not exhaustive it is suggestive. I had intended at one time to write a paper on the same subject, but the intention never got beyond the incipient stage. However, perhaps there is no loss, and I would propose now to epitomise what I would have then said in my remarks on Mr Galloway's paper. Mining surveys are frequently made in confined places, and it is therefore desirable that the instrument used be as light as possible, consistent with efficiency and durability. For that reason I would not be in favour of adopting Hoffman's Joint because of its weight, unless there is a decided advantage in so doing, and the advantage seems to me to be not very apparent. The ordinary ball-and socket joint is light and simple, and the adjustment speedy, and, for surveying, sufficiently accurate. Hoffman's Joint will, however, be very valuable in levelling, greater speed than is possible with the ordinary parallel plates being secured, as well as extreme accuracy of adjustment which is necessary for correct levelling. The circumstances in which the majority of surveys are made are distracting enough, and it is of consequence that the possibilities of error be reduced to a

minimum. The operator should, therefore, in my opinion, be to the utmost extent independent of agencies outside himself. On that account, as I stated at last meeting, as well as for the sake of speed, I believe the arrangement with the three tripods to be a good one, and for vernier surveying, worthy of general adoption. I should like to interject a remark with reference to what I said last night as to being as much as possible independent of officials at the colliery. It was suggested to me that this remark of mine might be misunderstood. I did not intend it as a reflection on the integrity of the workman. As a rule those who assist the surveyor are the roadsman or fireman, with sometimes the overs-man, but seldom the manager. I have never in my experience known a workman willingly mislead, but I have many a time seen one inadvertently do so by *e.g.* lifting the lamp and putting it down with the flame in the opposite direction from what he lifted it. Such things annoy a surveyor, and lead, especially in vernier surveying, to unsatisfactory results.

The PRESIDENT—I would just like to say I thoroughly understood what you meant. No one for a moment thinks a workman is not interested in the accuracy of the survey as far as he can do it; but he, without knowing it or thinking, puts it wrong, though he does not intend to do it, and I am sure every one appreciated your remark in that way.

Mr BARROWMAN, continuing, said—The sources of attraction —local and adventitious—by which the magnetic needle is drawn aside are more numerous than is generally known. The most common attracting matter is iron in the form of rails. In addition to masses of manufactured iron which are abundant in and about most collieries, iron may be present to a distracting extent in whin above and below ground: in slag or ashes lying in heaps on the surface or spread in the roads underground: in ironstone heaps and hearths, and even in bricks. I have found a common red brick divert the needle to the extent of 2°. When danger is seen it is easily avoided, but attraction may be at hand and the surveyor be unaware of it. A rail built in or covered with mud at a roadside, or buried under some rubbish in an air course, may baffle the unwary surveyor and vitiate his survey. Over and above the daily variations of

the magnetic meridian and its constant movement—presently eastward—at an appreciable rate per year, there are other and more occult causes of variation which it is not always possible to anticipate or take account of. In a scientific paper published in 1870, it was reported that observations had been taken of the variation of the magnetic declination in connection with the Aurora of 14th October of that year. These observations shew that within the space of two and a half hours the needle was deflected several successive times both eastward and westward from the mean direction to the extent of almost a degree, the greatest variations being 22′ 52″ eastwards and 32′ 19″ westwards. Conceive of an underground survey being made with the needle under conditions such as these. After fifteen years' uninterrupted practice in underground surveying, I think I might venture to offer a suggestion to managers who may wish to do a really correct thing in say, driving a "march place" so that no superfluous coal may be left on the march. The suggestion is, don't try it. Such an undertaking is subject to several influences over which we have little or no control. A barrier along the march serves several good purposes. Among others it allows a margin for errors in surveying from inadvertence or other causes. As to the reading and booking of angles: the mode practised by some of reading each quadrant of the circle independently, as *e.g.* 20·N.E. 25·SE., is liable to the objection that the surveyor has to read sometimes from the right and sometimes from the left to the needle. If the bearings be read from the complete circle right round to 360° the eye becomes accustomed to read always in the same direction towards the needle, and the chances of error in the reading are fewer. In vernier surveying or traversing (or surveying with fast needle as it is also termed in England), I have latterly been in the habit of working with the loose needle at the same time, the survey being thus carried on by vernier and "variations" simultaneously. In this way the accuracy of the vernier work is tested all through, not only in the manipulation of the instrument, but also in the marking of the bearings. I think it well in taking account of the magnetic meridian, not to depend on a single sight between two fixed points. The smallest want of balance of the needle affects the reading as is seen from

the fact that the two ends of the needle rarely record alike. It is therefore safer (in addition to taking up some surface lines in relation to the underground workings at a first survey) to fix a peg in an open situation which has first been proved to be clear of attraction and view all round to promiment objects as *e.g.* church steeples, lightning conductors, &c., noting each bearing in the survey book. The average difference in the respective readings noted at each survey determines the change in the magnetic meridian. Unless where the strata are highly charged with iron, so that the needle cannot be used, results obtained by careful and repeated observations of the needle are satisfactory for ordinary surveys and even in many cases, provided the instrument be in perfect order, for surveys in connection with mines meeting one another on the same line from separate pits. Regarding the methods of connecting the survey of the underground workings with the surface by means of the transit instrument or by plumb lines of wire down the shaft, I cannot speak from experience, not having tried either or seen it tried, but I have great respect for the method and the man that produced the results submitted to the North of England Institute by Mr Beanlands some years ago. For surveying highly inclined workings, the see-saw arrangements of the sights or vanes is useful; but it adds weight to the instrument, and the slightest twist in the spindle or centre pin would swerve the sights, in which case a line from the one to the other would not be a true diameter of the graduated circle which it ought to be. I prefer therefore to have the sights fixed to the graduated plate, and, indeed, I would like to see them cast in the same piece with it. A movable sight or vane, which may be carried in the pocket, and slipped on the top of either of those on the compass when wanted, is what I have been in the habit of using, and it is quite satisfactory. In circumstances such as are stated by Mr Galloway, I have no doubt his levelling instrument is useful. I do not suppose, however, that in very steep workings levelling will be done by it more quickly or correctly than by the straight-edge and spirit level; and I would much rather use the ordinary levelling instrument with Hoffman's joint in flat workings. The mode of marking the levellings advocated by Mr Galloway has been in use in the west of Scotland for the last 20

years, the levelling being carried forward periodically and marked on the plan along with the survey, and the datum used being usually 1000 feet under sea level. In a mining district, it is necessary in levelling from a B. M. to make sure that it has not been affected by workings underneath.

Mr R. T. MOORE—Mr Barrowman mentions the deflection of the needle during a display of aurora-borealis. I had an impression that these deflections required to be measured by a very sensitive needle; and that they were so rapid that they would have no effect on an ordinary surveying compass.

Mr DIXON—The one thing that is really new to me is the adoption of three tripods in making vernier surveys. I think it might be a good plan, but I would like to try it before making up my mind. To level with tubes as described, I think may be found advantageous in many circumstances, but I agree with Mr Barrowman that in ordinary drawing roads, the level is better adapted for end work. In regard to surveying generally, I am a great believer in the needle. There are some compasses I have come across in my experience which are much more sensitive to deflection than others. I do not know what is the reason of this, but it appears to be something in the temper of the needle itself. I consider with an instrument of that kind, and surveying with short lengths, very accurate surveys indeed could be made. A most common and annoying thing is local attraction. I have come across that over and over again. Another point in surveying to be noted by young surveyors is to take every check that is possible. To save a little work in the pit an opportunity of checking is passed; this is a great mistake, and is generally regretted when the plotting is being done.

Mr BEGG was glad to hear Mr Barrowman condemn the reading of the dial by quadrants, and thought that if surveyors would lay aside their prejudices and give the other method a trial, they would not require to be urged to do so twice. He pointed out the trouble and the danger of making an error which was repeated four times for every point of the quadrant. First, in the observation of the needle, you read one side one time, the other side the other. He knew thoroughly the advantage of the change, for, having been trained to the system followed

by the President in reading and recording by the quadrant, he was advised to try reading all round—and found it such an ease to his mind as to be a luxury—and he advised all to try to secure the same enjoyment.

Mr ROBSON, referring to the remarks of a previous speaker as to contour lines, said that to his knowledge they had been so taken in England for twenty years.

The discussion, on the motion of the President, was adjourned.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 9th DEC., 1881,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

RALPH MOORE, Esq., President, in the Chair.

The Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentleman was balloted for and admitted as an Ordinary Member:—

PETER MOFFAT, Civil and Mining Engineer, 14 Ure Place, Montrose Street, Glasgow.

The following was nominated for election at the next meeting:—

JAMES HARDIE, Colliery Manager, Benhar, Whitburn.

SOME REMARKS ON MINING INSPECTION IN BELGIUM,

Compiled from a Report by MM. Pernolet and Aguillon.

BY MR ROBERT T. MOORE.

A COMMISSION has recently been appointed in France to report upon the means of preventing explosions of firedamp in their coal mines. They appointed two of their number—MM. Pernolet and Aguillon—to visit the mining districts of Belgium, England,

and Germany to report upon the measures which have been taken in these countries in the working of fiery mines, and especially the manner in which official regulations are applied. The report of these gentlemen is in three volumes—one for Germany, a second for England, and a third for Belgium. I have translated that for Belgium, and have made the following abstract of it:—

There are two Acts regulating fiery mines in Belgium: (1st) that of 1st March, 1860, modified by that of 8th April, 1858, concerning the ventilation, lighting, and the use of gunpowder; and (2nd) that of 18th June, 1876, which is specially devoted to lighting. These form a rigorous and minute set of regulations, the most rigorous found in any country, and would bear very hard upon coalmasters but for the provision empowering the administration to authorise exemptions to the most absolute rules of the two Acts if it find it necessary to do so.

In a general way the administration sees that all the provisions are observed, only the coalmaster is entitled to demand and obtain, with or without conditions, all the exemptions which the working of his mine enables him to ask. The Government arrangements are such that generally no difficulty is met with in these exemptions.

Government inspection in Belgium is very much more minute than either in France or England. The minerals belong to the Government, and the coalmaster pays lordship to it. In addition, therefore, to their duties as Government Inspectors as understood in England, they have to ascertain if the colliery is well worked from a landlord's point of view, and also the amount of lordship payable to the State. They are, therefore, more numerous, the pits, in the case of fiery collieries, being visited at least four times in a year.

These frequent interviews between the engineers and the coalmasters appear to contribute to the maintenance of the harmony and good relations which appear to reign throughout. Usually, whenever the coalmaster wishes to do any work which might not be conformable to the regulations, he acquaints the inspector and comes to an arrangement with him before doing so. Generally the work is begun immediately afterwards, unless the exemption does not come under a simple authorisation of the inspector laid

down in the register of orders, or a simple tacit authorisation, when it is necessary further to refer the matter to the Permanent Deputation.

These exemptions are all the more necessary as the Belgian regulations do not make any distinction between the very fiery mines subject to instantaneous outbursts of gas, and the feebly or partially fiery mines. Legally there only exist in Belgium mines without gas and mines with gas, and subject to *all* the regulations of the Acts of 1850 and 1876.

Previous to the Act of 1876, it appears that there was a certain classification of seams which were considered to be fiery, and every mine working any of these seams was considered a fiery mine, even in collieries where these seams did not give off fire-damp. Since this Act, in order to constitute a mine a fiery one, it is necessary to make an inscription to that effect on the register of orders of the colliery.

The law is very suitable for very fiery mines, or those subject to sudden outbursts of gas. So much so, that one of the most qualified engineers of a very fiery coking coal colliery said, that even if it were not law he would take it for the conduct of his mine: the more so as it was not troublesome in reality where one knew to prepare his workings with a view to adopting it. The owners, however, of slightly fiery collieries felt that the regulations were too stringent, and objected to being put under the same regulations as the very fiery mines. Objections were also taken to the exclusive use of the Mueseler lamp. In consequence of these objections, a commission, composed partly of officials of corps of mines and partially of coalmasters from the various basins was appointed for the revision of the Police Regulations on Mines, and the subject is still under consideration.

There is a distinction drawn between mines where the discharge of gas is normal and those which are subject to sudden outbursts, and the regulations are slightly different.

In Belgium, the gas almost always comes from the coal itself, and it is only in rare instances that blowers are met with in any measures outside of the seam.

None of the outbursts of gas outside of the coal appear to be

comparable either in frequency or copiousness with those which are found in certain English districts.

The following example is given of the pressure of the gas in the coal. At Bellevue, No. 7 Pit of the West of Mons, M. Soupard shewed the following experiment to the Commission. A borehole of 26 feet in length and 2¼ inches diameter was bored into the face in the Petite-Chevaliere seam at a depth of 287 fathoms.* A pressure gauge was placed at the extremity of a tube, inserted in the hole, and the pressure rose to six atmospheres in six minutes. The pressure afterwards remained constant, but the joint of the pipe with the gauge leaked considerably.

The sudden outbursts specially occupy the attention of the coalmasters, and the Administration. It has been proposed to adopt a special set of regulations for mines of this character. The following are descriptions of two sudden outbursts :—

At Agrappe, No. 3 and 12 Pits, in the first six months of 1880, there were eight sufficiently characteristic sudden outbursts. These took place at a depth of 260 fathoms in No. 12 Pit, and 332 fathoms in No. 3, in the Chauffournoise seam of 3 feet in thickness, and the Cinq Paulmes of 3 feet 11 inches in thickness. None of these outbursts were of any great importance ; the most important, that of the 23d April, only threw over 20 tons of coal. In one of them a workman was thrown down, but he got out without injury. The lamps were all put out in the same stall, and in the stalls to the rise by which the return air current passed. In these eight cases, the preventive bores which were regularly made gave no result.

The two sudden outbursts met with at North Marcinelle on 30th April and 27th July, 1880, were more serious, a workman having been buried under the coal in the first case, and two being suffocated in the second. The two outbursts took place at No. 6 Pit in the 10 Paulme seam, which has a thickness at this point of from 2 feet 8 inches to 3 feet 6 inches. The face was 200 fathoms deep, and 145 fathoms from the cross-cut in the first case, and 206 in the second.

* This was one of the three boreholes which generally go in advance of the workings in seams which are subject to sudden outbursts such as the Petite-Chevaliere at Dour.

The seam is nearly vertical in this district. At the first accident a fault was encountered, in leaving which the two last faces alone were working. The amount of coal thrown down was 2500 cubic feet. All the lamps were put out by the gas in the eastern district, and by the concussion of the air in the western, when it was seen after the accident that the gas filled the advance mine near to the crosscut.

At the second accident the outburst was yet more important; it took place at the coupure.* The current of air was instantly reversed and the gas flowed back nearly into the crosscut where it put out lamps at more than 550 yards from the point of outburst. The two workmen were suffocated at the face of the main gallery; a third was able to save himself by passing over their bodies. At the moment of the second outburst the fault had been passed, and the stalls were extended all along the district.

In both cases there were boreholes of 23 feet in length and 1¼ inches in diameter preceding the face. They were not, as is seen, of more use here than at Agrappe.

There are always at least two outlets to each seam, and no one would think of working with one. For very fiery mines, and especially for those subject to sudden outbursts, there are three outlets demanded by the Administration. In addition to the winding pit and upcast there must be a pit with ladders in it for the workmen to ascend.

The most frequent type of fitting consists of two pits more or less near, one of which, always the principal winding pit, forms the downcast, and the other the upcast. The last is generally kept exclusively for this use. In some cases the upcast is a winding pit, and more rarely one by which the men descend. Besides these, there is generally a ladder pit, and, if necessary, a

* In Belgium what is called the coupure is the face of the main gallery which always precedes the workings or opening-out places along a district comprised between two levels.

special pit for drainage. The ladders are often put in this pump-pit. The ladder pit may be as in the old fittings in Borinage, composed of a series of small blind pits (tourets) dug from one level to the other, but in the new fittings it is a working pit of large diameter.

In such a fitting, the field being determined, the upcast is essentially more or less near the downcast, and makes part of the same external fitting. In many of the recent fittings they are not more than 38 yards apart.

In Belgium, as will be seen further on, ventilation is produced solely by fans, and the fan is always built at a certain distance (sometimes 100 yards) from the mouth of the upcast, with a fan drift joining it.

At the Colliery of Produits, in the west of Mons, the return of five downcasts, all winding pits, Nos. 12, 14, 18, 20, and 23 is made by three special pits, Nos. 13, 10, and 11. No. 13 Pit is connected with No. 11 by a gallery of 540 yards in length, and the return is made by these two contiguous pits which form the central ventilating fitting. Three fans, of which one is a spare one, are fitted in the same building and serve to draw the air. This arrangement is not much thought of, and in the new collieries the type of fitting with a special upcast near the downcast is returned to.

At the Seraing Colliery, the four winding pits have each their ventilating pit furnished with fans,—only the fan of one fitting draws out a part of the air from some one of the other collieries.

These are peculiarities which have been selected, but it is seen that in Belgium every mine has at least a downcast and an upcast without having recourse under ordinary circumstances to bratticed shafts.

Upcast shafts are seldom used for winding or for any other purpose then ventilation. Before an upcast can be used for any other purpose permission has to be granted by the Permanent Deputation, and it is generally done under certain conditions which are specified in the Act authorising it.

The following are the conditions under which winding has been permitted in the upcast of the Chaumonceaux Pits of the Amercœur Colliery, in the Basin of Charleroi :—

Art. I.—(1) The volume of air circulating in the workings of the two winding pits of the Chaumonceaux Colliery shall be at least 85 cubic feet per minute per workman of the largest shift.

(2) The currents of air coming from the working ought always to open into the pits for ventilation higher than the landing stages in use, which shall be ventilated with pure air.

(3) The stages for hanging on and landing, established in the ventilating pits and in circuits, shall be lighted by lamps of the Mueseler system, which shall only be relighted at the surface and outside of the erections. No furnace shall be inside of the circuit.

(4) In view of lessening the consequences of a possible explosion, safety doors shall be applied to the roof or upon the sides of the passages opening to the upcast pits, so as to prevent the reversal of the air ; and in addition they shall establish in the circuit at the level of the surface some safety valves so as to be able to shut the pits.

(5) Except in cases of emergency, travelling of workmen in the upcast is expressly forbidden. The persons allowed to travel in this pit shall be the agents of the colliery charged with the interior superintendence, and the workmen who shall have to make repairs to it.

(6) The managing engineer of the works himself shall watch the rigorous observance of the above conditions.

Art. II.—The present authorisation shall always be able to be repealed, and the engineer of the district, if he sees a cause of danger, may suspend it, but he must immediately inform the Engineer-in-Chief-Director.

Art. III.—In case the conditions imposed are not observed, the contravening parties shall be prosecuted in accordance with Title X. of the law of 21st April, 1810.

It is customary in Belgium to have under the same roof the pit itself, the winding engines and other sets of engines, and the engineer-in-chief has issued a circular excluding naked lights from the top of the pit and the buildings, in pits working seams liable

to instantaneous outbursts of gas. At some places, in order to comply with the circular, the gas-burners or the lamps were put in a perfectly close glass lantern, and the air for the combustion was taken from the exterior of the building by a tube, the opening of which was protected by wire gauze. Instead of having the old-fashioned brazier on the pithead, they proposed to heat the building by discharging the exhaust steam into old boilers placed inside.

The methods of working in Belgium may be classified as pillar-and-stall and long-wall. The method of pillar-and-stall is the less common, and the following is a description of the working as applied at Hasard to seams of 4 to 5 feet in thickness, inclined at from 1 in 6 to 1 in 3. These seams are non-fiery, or only slightly so.

The working is made from the pits or principal cross-cuts in successive districts of 433 yards in length. Each district is traced out from an inclined plane following the dip and rise, by galleries, forming pillars 11 yards wide following the dip and rise, and 22 level. These are afterwards taken out in lifts, commencing at the most distant and highest pillar—the wood being drawn and the roof allowed to fall as in ordinary pillar-and-stall working. The air goes along the faces going through the last place put through, between the two levels, and instead of bratticing being used to send in a current of air to the faces a small hand fan is used to drive air in through sheet-iron pipes 10 inches in diameter. The one fan sends air into both the place going level course and into that going to the rise. In taking out the pillars the ventilation is made by diffusion. The Commission remark—This is done in the slightly or not at all fiery seams, which explains the tolerance given by the Administration to a working which may be, as is seen, far from following the prescriptions of the Act of 1850.

Long-wall is generally similar to that worked in England. All the fiery seams appear to be worked by this method. An important general characteristic to note in these long-wall workings is that the vacancy is almost completely filled up. In the thin seams of Borinage or Charleroi, the "stowage" is so abundant that some

times 60 for 100 of coal are taken to the surface. In the thicker seams of Liege of 3 feet 3 inches and over, where the stowing furnished by the seam itself would be insufficient, rubbish is taken from other seams worked at the same time.

With the methods of working indicated above the general arrangement of the ventilation is pretty clear. The air arriving by a cross-cut, or more generally by the main road of the inferior stage, divides itself between the seams. If the seam is worked on two sides, which is the general case, the current for each seam is split into two branches, the one for the workings to the right and the other for those to the left. Each of these secondary currents follows the bottom road of the seam nearly to the face and goes along all the faces from the lowest to the highest which is the return. Generally, there is, in each pit, one stage in full operation, a second in preparation, and often a third completely finished.

The fundamental precaution prescribed by the administration, and followed pretty faithfully by the coalmasters, is the limitation of the number of stalls in operation at the same time in the one current of air. This number is regulated in each case by the quantity of gas which the seam gives off normally or is able to give off, and is fixed so that the air may never be too highly charged with gas on arriving at the last stall. In fact, the whole working is organised on the proportion which the number of stalls working, or more exactly the surface exposed each shift, in a given current of air bears to the intensity of the disengagement of gas. If necessary, the Administration would interfere energetically, to cause them to respect this principle which is considered as fundamental.

In some slightly fiery seams they may have thirteen successive stalls in activity at Poirier, while in the very fiery seams they may not have more than two or four, as at Beaulieussart, and sometimes only two; generally in fiery mines there are only four to five walls in activity at a time in the same current of air. A stall is here understood to mean an ordinary long-wall wall of from 18 to 20 yards in length. If the long walls of Seraing of 50 to 60 yards were taken, then there would be only one or two in activity.

In order to limit more conveniently the length of the face in operation, recourse is freely had in certain mines to a division into smaller stages. The following is a very clear case of it:—

At Bellevue No. 7 Pit of the Collieries of the West of Mons, which is a very fiery mine and subject to sudden outbursts, the stage is usually 76 yards. The main preparatory works, sinking of the pits, driving the crosscuts and airways are made upon all the height of the stage, but for the working properly so called they branch out as shown in the sketch opposite (Fig. 1), upon the main crosscut at a sufficient distance from the seams, a rising crosscut, shewn *a b*, which cuts out the stage in two. The bottom roads in each seam are only made from the intermediate level *a c*.

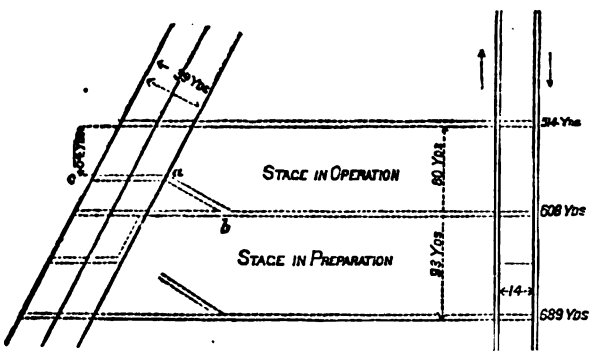

FIG. 1.—Subdivision of the stages of working of the Bellevue Pit of the Collieries of the West of Mons.

In mines subject to sudden outbursts, they are inclined to limit the daily advance of the face, in case of weakening too rapidly the pillar of coal which exists between the face and the unknown point of the seam where there may be a centre of a sudden outburst.

In large Belgian Collieries, therefore, the staff is so arranged that each working place may advance regularly, each working

shift by a quantity which varies from 4 to 8 feet, but which in fiery mines is scarcely 4 to 5 feet. Sometimes the speed is still further reduced by giving the workman a double place instead of one. In some mines this has been prescribed, or at least strongly advised by the Adminstration, but it has been objected to on economic grounds, and it is not insisted on by them.

A point which has not been made the object of any prescription deserves all the more to be noticed in the working by long-wall. This is the distance to which they are able to draw from the inclined plane which takes the coals from the faces. Generally this length is limited only by considerations relative to the drawing and maintenance of the road. One would like to ask if apart from these considerations, it is not inconvenient to create between the inclined plane and the face, a sort of *cul-de-sac* placed in the middle of the stowing, and which is only aired by the escapes of doors placed along the inclined plane. The lengths of these galleries which the Commission saw were in general of 150 to 200 yards, but there are some 300 and even 400 yards as in the Saint Auguste seam of the colliery of Anderlues, where an explosion took place on the 1st April, 1880, in which 49 persons were killed. This explosion occurred at night when the brushers were down, and the gas was supposed to have ignited at one of their shots.

The preparatory workings of a stage comprehend essentially, 1st, the sinking of the pits; 2d, the driving of the crosscut to form the new stage; 3d, the driving of the gallery which puts in communication, following the seam, the bottom level with that of the higher one in working. The bottom road in the seam may make part of the preparatory workings, but generally it will be driven with the working itself.

For sinking pits and driving level galleries, whether in stone or in coal, the Administration allows the coalmasters to act freely under their own responsibility, provided that they conform to this rule, pretty faithfully observed by all, that the return air of any preparatory work whatever goes directly to the main return without passing other working places. Sheet iron pipes of from 10 to 14 inches in diameter are used for the ventilation of all

these workings. Occasionally double lines of these pipes are laid.

The blowing tube is generally preferred in fiery mines, although in Borinage for very fiery mines, or those subject to sudden outbursts, they prefer to employ both blowing and sucking tubes.

Following the fundamental principle of ascensional ventilation, enacted by article 7 of the Act of 1850, a coalmaster cannot drive any place to the rise in which the air has to return down hill without an Administrative authorisation.

The principle of ascensional ventilation in the ordinary working is for the whole of Belgium a strictly applied dogma, to which exemption is only granted when it would be impossible to do otherwise, when especially the work necessary to render the ventilation ascensional would absorb all the profits to be drawn from the working of the part of the seam in question.

In ascending ventilation, the air goes from the lowest point of the face to the highest, and is conveyed from thence to the upcast by a road which is either level or rises all the way.

In descending ventilation, the air goes along the face from the dip to the rise, and, after arriving at the higher extremity, instead of going directly either level or rising to the upcast shaft after the usual and legal arrangement, it is brought back downhill by a special return. Another form rarely resorted to is to allow the air to enter at the highest face and return at the lowest.

Exemptions from ascentional ventilation are sometimes granted, but under very stringent conditions, as will be seen from the following examples:—

Resolution of the Permanent Deputation of the Province of Liege, authorising the Cockerill Company to work with descending ventilation to the distance of 380 yards from its Marie Colliery at Seraing, two pillars of the Houlleux seams shewn under number A and B of the plan, and situated upon the two sides of a saddleback, of which the crest is formed by a dislocation (XY) met with at a level of 358 yards.

Whereas, it appears from the reports of the engineers that there is reason for granting conditionally the authorisation solicited, and to extend it to a third cutting, point D on plan, established at the level of 380 yards, and which ought to be ventilated by the same current as the cutting A.

Considering the Royal Act of 1st March, 1850, modified by that of 8th April, 1858,

The Permanent Deputation enacts :—

The authorisation asked is granted under the following conditions :—

1. Working must not take place simultaneously on two sides of the saddleback.

2. A current of fresh air, of which the speed must not exceed 8 feet a second, shall run along the face ascensionally, and shall deliver at least $1\frac{3}{4}$ cubic feet per workman of the most important shift.

3. The return air-way shall have throughout a minimum section of 15 square feet, and its inclination shall not be in any case greater than 1 in 3.

4. The doors for directing the current of air shall at no point be fewer than three.

5.—The employment of powder is interdicted for all purposes in the working which is the object of the present authorisation.

6.—A special superintendent, not working, shall be constantly attached to these workings day and night, whose duty it shall be to superintend the ventilation and lighting, and to make the miners leave the workings on the least appearance of gas.

7.—The administration of the mines may suspend the effect of the present authorisation if it recognises any cause of danger whatever, or prescribe eventually any measures of safety it may deem necessary.

Resolution of the Permanent Deputation of Hainault, of the 16th May, 1879, authorising a working with descending ventilation in the Maton seam at No. 4 Pit, called Neuville of the Grand Mambourg Liege Collieries.

The authorisation is granted under the following conditions:—

1.—The air current shall constantly be ascensional at the faces.

2.—The number of stalls in operation at a time is limited to three producing about 36 tons a day.

3.- The faces shall be aired by a current of fresh air, making its return by passages which shall be accessible only to the workmen charged to visit them and keep them in good order.

4.—Arrangements shall be made by the direction of the colliery so that the abandoned workings are not able to injure in any way those in activity.

5th.—The employment of powder is prohibited for any use whatever, and only Mueseler lamps shall be used for lighting.

6th.—The workings shall be constantly examined by special porions designated as such upon the list of persons employed (*registre de contrôle*), and by the engineer charged with the usual superintendence of the colliery.

7th.—The workings thus authorised shall be abandoned as soon as gas shall appear in the faces or in the roads, also at the first requisition of the engineers of the mines.

8th.—The engineer director of the workings shall watch himself that the preceding prescriptions are rigorously observed.

Great care is taken in splitting the air and dividing the ventilation into districts, so that if an accident were to take place in one it would not be communicated to the others.

The Commission did not hear of any mines in Belgium which were ventilated by natural ventilation only, and they did not believe that any existed. Furnaces have equally completely disappeared. It would be difficult to have them in mines where the Administration tolerates with reluctance the re-lighting of lamps for the workmen underground.

This being the case, fans are solely employed in Belgium for the circulation of the air. The report goes very fully into the subject of fans, but as it has already been very fully discussed before the Institute, it is not necessary to go into it any more fully than to say that the fan chiefly employed was the Guibal fan. Details of the various fans are given in the table (page 281). The arrangements are similar to those generally in use here. The most of the fans recently erected admit the air

from both sides. In many mines they have two fans and two engines to each mine, only one of which works at a time, the other being kept for any emergency.

The Ministerial circular of 15th September, 1873, fixed as a basis for the quantity of air to be passed in all mines a quantity of 62 to 104 cubic feet per minute per workman of the largest shift. This quantity is generally largely exceeded in fiery mines, where they have to pass round the faces a sufficient quantity of air to dilute the gas and render it harmless without exceeding a speed of 6½ feet per second at the faces. The circular seemed to refer to the faces themselves rather than to the whole of the mine. The quantities of air in the mines visited are given in the table page. The average quantity of air per workman per minute for ten mines was 189 cubic feet per minute, with a minimum of 82 cubic feet, and a maximum of 325 cubic feet. The quantity of air per minute per 100 tons extracted gave an average for 15 mines of 17,400 cubic feet per minute, with a minimum of 6,227 cubic feet per minute, and a maximum of 35,285 cubic feet.

If the total equivalent orifice* is taken for 15 mines, it is seen that the mean of these orifices is from 10·76 to 12·80, varying between a minimum of 8·39 to a maximum of 28·08 at Marihaye.

If this mine, which is a large one, be left out, the average of the 14 others is 11·62. It is seen from that, that the mines visited by the Commission were average mines, and that their average gives exactly the figure which charactertises those mines given by M. Murgue.† These mines represent about the average

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* This notion of equivalent orifice, invented by M. Murgue, is much used in France, and is so useful that it seems worthy of explanation. A mine being given, when a watergauge (h) is produced a determined volume of air (V) is passed through it. The resistance of the mine is considered as being the same as that due to the passage of the air through an orifice (a) in a tin plate of such dimensions that when there is a difference of pressure (h) between the two sides of the plate, the volume (V) passes through the orifice, the section of which in square feet is a very simple way of characterising the mine from the point of view of the ventilation.

The manometric efficiency of a fan is mentioned by the same writer and is also worthy of mention If V represent the velocity of a centrifugal fan, then $\frac{V^2}{33{\cdot}2}$ is the highest possible depression it can produce. This is never got in practice, but a certain fraction, $k\frac{V^2}{33{\cdot}2}$. k then is the manometric efficiency of the fan.

† Bulletin de la Société de l'industrie minérale, tome IV. de la 2ᵉ série pages 760-761.

of the fiery mines. In the same work, M. Murgue stated that, while the equivalent orifice calculated from the published results of old Belgian mines was 6·13, it was 8·47 square feet for the period after 1859. From the figures now given by the Commission, it would appear that the Belgian mines, instead of becoming narrow mines, had become average mines. This result has been produced chiefly by the adoption of a pit of large diameter for the upcast, and by the increase of the size of the pits and passages.

There is often a considerable difference between the quantity of air as measured at the entrance to the fan and that measured at the bottom of the downcast, and afterwards usefully employed in the ventilation of the workings. Thus at Agrappe, No. 3 Pit, the loss reached 36 per cent. of the total quantity leaving, and 56 per cent. of the useful volume entering. These differences depend upon peculiarities in the fittings.

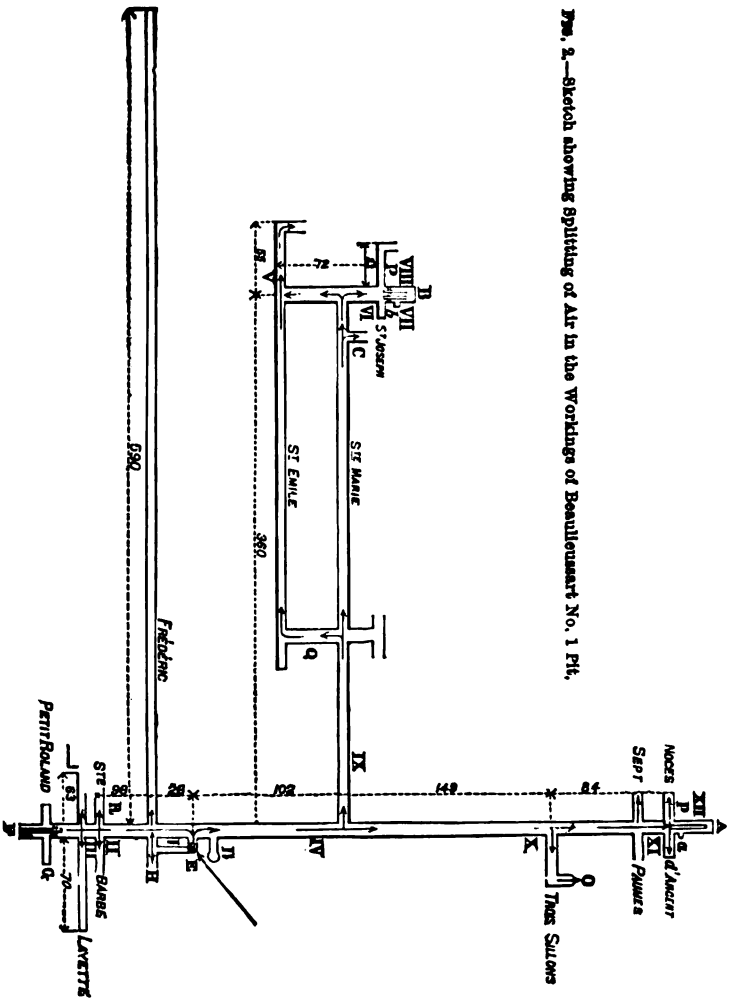
It is of importance to note that in the Belgian collieries, in consequence of the arrangement and methods of working, the air entering the main ways from the bottom, and consequently the air entering in the crosscuts from the pits passes nearly whole to the working places themselves. There is not any real loss by the inclined planes, which form besides the face the only communication from one level to another, the top of the inclined planes, being always close, the air, which is able to escape by the doors leaving the inclined plane at each branch, returns to the face of this passage; it is, on the whole, only a sub-division of the current of air, which is useful in many respects. It follows, that with a relatively small volume entering at the bottom of the pits, especially if it is compared with that of English workings, there is still a considerable ventilation in the working faces.

The following is an example of the inner distribution of the air, which was noted by the Commission, and the measurements made by them during their visit to the No. 1 Pit of Beaulieussart Colliery. The sketch and the accompanying description (Fig. 2) gives all the necessary information on the subject.

No. of Stations of Measurement.	Description Of the Working Places in activity at the stage of 380 yards.	Workmen.		Output.	Quantities of air passing into the working places.	Quantities of air per minute.			No. of Measurements.	Remarks.
		In the Seam.	All included.			Per Collier.	Per workman at the bottom.	Per ton raised.		
										Thickness of Seams.
I.	Working of Layette (three places), ...	15	21	46	41,936	167	120	49	III.	Layette, 2′ 1″.
II.	Working of Frédéric (one side), ...	..	..	..	49,491	..	..	..	I.	Frédéric, 2′ 11″.
III.	Working of St. Emile (four places), ...	12	29	90	48,184	239	109	32	VI.	St. Emile, 2′ 7″.
IV.	Working of St. Marie (one place), ...	3	8	8	65,022	1302	488	488	IX.—(V. + VI.)	St. Marie, 1′ 9½″.
V.	Working of St. Joseph (one place), ...	4	14	20	43,737	655	137	131	VI.—(VII. + VIII.)	St. Joseph, 2′ 6″.
VI.	Working of Seven Paumes (two places), ...	7	16	36	46,384	396	174	76	X.—XI.	Seven Paumes, 1′ 8″.
VII.	Bouveau North, at 325 yards,									
VIII.	Bouveau in preparation, at 380 yards, ...	..	3	..	5,083	..	102	..	VII. + VIII.	Noces d'Argent, 2′ 0″.
IX.	Working Noces d'Argent (six places), ...	24	58	72	95,557	237	97	78	XI.—XII.	The seams are inclined at from 1′ in 1′ to 1′ in 2′.
X.	Bouveau North, at 380 yards,	..	3	..	3,565	..	70	..	XII.	They are worked by longwall with 20 yards between the roads in a single stage between the levels of 380 and 325 yards.
	Total of Works, from 1. to X., Repairs to Roads, &c., ..	65	168	272	476,890	445	172	106	I. + II. + VI. Plus a tube.	The St. Emile seam is extremely fiery.

N 1

FIG. 2.—Sketch showing Splitting of Air in the Workings of Beaulieusart No. 1 Pit.



A F, Crosscut from the stage of 386 yards.
A, North face. In operation, ventilated by a single tube.
a, Chimney isolated for the return of air from the face of the crosscut.
F, South face. Standing, ventilated by a single tube.
O, Inclined plane in the Trois Sillons seam leading the air to the Saint Paul seam, and to the crosscut north from the stage of 328 yards.
Q, Old crosscut from waste.
G, Stall in Saint Marie seam.
B, Crosscut in operation, ventilated by two tubes.
b, Chimney isolated for return of air from the face.
D, Interior pit for sinking under the winding pit.
E, Winding pit and intake.
H, Old workings, ventilated by a split.
G, Chimney isolated for the return of the air from the face of the crosscut.
P, Regulating door. Regulating the entry of air to the south district.
P P P, Double doors, forcing the air to go by the tubes.
The Roman figure indicates the position where the volumes of air given in the above table are measured.

With the relatively small, but well distributed quantities of air of Belgian ventilation, there is not, except in some exceptional passages, an excessive speed. Outside the narrow passages, near a door for example, the great speeds are found in the cross-cuts. They are generally 43 square feet of section; and there may be nearly, with 34,000 cubic feet per minute, an average speed of 13 feet per second. The speed of 16½ feet per second has been pointed out as the maximum speed which has been noted in a gallery of a district of Borinage, where the Administration causes frequent measurements to be made. The bottom ways in the seams have a section of 32 square feet, and the speed scarcely exceeds 3¼ feet. At the faces themselves it is admitted that the speed ought not to exceed 6½ or 8¼ feet per second at the most for the convenience of the workmen, and it did not appear that there were many places where this maximum was attained.

In consequence of the small development of a stage in height and of the independence of the currents, the circuits travelled by the air are not generally of very great lengths, especially in fiery mines. Several were noted by the Commissioners of about 2700 yards from pit to pit. Those above ought to be rare, as it is admitted in theory, that a cross-cut may go to 1200 yards from the pit, and a face to 2700 yards from the cross-cut.

The Commissioners did not see a mine which had a special plan shewing the ventilation. There are very few of them where periodical measurements were made. At Produits, the register of the ventilation, which is very regularly and well made, is kept after the following model:—

Number and Place of Observation.	Time of Observation.	Turns of Anemometer.	Speed of the air.	Section.	Volume.	Number of Workmen.			Night Shift.	Litres per Workman.		Output.	Litres per Ton.
						In the Seam.	Others.	Total of Day Shift.		In the Seam.	Total of Day Shift.		

The stations are selected for the purpose of making known, not only the general distribution, but also the quantity of air really passing to the faces. The Biram Anemometer is used. It is held in the hand all over the section and the mean of three similar observations is taken.

The measurements are made more especially by the officers of the mines. In certain districts the engineer ought to make the measurements of the total distribution once a year; in others, these would only be made at the expiry of a more or less long period.

The fans are all supplied with water gauges, but very few have counters of the revolutions of the fan. The Commissioners mention a tell-tale for registering the water gauge, called a mouchard, similar to those in use in gas works and to that at Earnock Colliery, and they describe it thus :—It is a bell of air plunged into water, acting as a float, and working vertically, following the variations of the depression. The bell carries a stalk, with a pencil on the top, which traces the depressions on a revolving cylinder, driven by a clock.

It seems to be the general impression in Belgium that the discharge of gas from old workings is influenced by the rise and fall of the barometer, and some have gone the length of endeavouring to send a stream of air through the goaf. The Commission give instances where special precautions are taken to increase the quantity of air passing through the mines in the event of a falling barometer. In Borinage, in several very fiery mines of the southern district, the use of powder in the brushing is absolutely prohibited during pronounced falls, and at the same time the speed of the fan is increased. At Crachet Picquery, a barometer is fitted into the engine room of the fan as well as the water gauge, and a written instruction fixes the depression the fan ought to produce following the state of the barometer —

2·73	inches	for	30	inches	of mercury.
3·12	„	„	29·6	„	„
3·51	„	„	29·2	„	„

The Commissioners also saw at Sacré Madame Colliery, Timmerman's Apparatus by which it is proposed to regulate the opening

of the valve of the engine driving the fan. This apparatus is the same as that shewn at the Paris Exhibition of 1878.

One of the engineers notes that most winds blow following a downward direction and that on this account the ventilation of mines whose upcasts were not sheltered on the top would be affected whenever there was a high wind.

The organisation of the work and of the superintendence is essentially the same for the whole of Belgium. For the working there are everywhere two principal shifts, one for the day which is nearly exclusively the shift at the coal, and the other for the night which is occupied almost exclusively in the brushing of roads and stonework. Each of these shifts has its special drawing arrangements. The drawers do not generally go down the pit till after the shift and remain after it. In addition to these two principal services there is a repairing shift which is generally in the mine with the stonemen. In the West of Mons the colliers descend between three and four in the morning and leave between one and two in the afternoon, while in the other places they do not descend till about six o'clock in the morning. There may be a slight interval between the succession of the workmen of the two shifts but it cannot be said that the mine is really abandoned during any part of the day's work. Sometimes the division between the stone shift and the coal shift is not so well defined. Thus for the relatively thick seams they do the holing at night and the colliers during the day have only to take down the coals. In this case, however, the holing and the brushing are not done at once in the same stall, at least if the latter is not done without the use of powder. They work coal on one side of the seam, while they are brushing the roads on the other.

In the thicker seams worked by pillar and stall there is no stonework, and so they work two consecutive coal shifts.

The care of the mine underground seems to devolve upon a person called a *chef-porion* who appears to correspond to our oversman. He remains in the pit the whole of one shift. There is another *chef-porion* on the night shift, who, although of the same standing takes his instructions from the day *chef-porion*. Under these *chef-porions* are *porions*, who seem to correspond to

our deputies or firemen, their number depending on the size and danger of the mine. In addition to this in the long-walls of Liege of fifty-five yards one of the miners, called a chief of a face (*chef de taille*), looks after the stall and has charge of the men. He appears to correspond to the stallman of the Derbyshire district.

The Commissioners say that the mine in Belgium is never visited before the descent of the workmen and they give as the reason for this that it is never properly speaking abandoned. Only it is the rule that all the working places should be visited at night by the *chef-porion* before he ascends to the surface; and the lamps are not distributed to the day shift until he has given his report to the *chef-porion* of the day shift, so that if there is anything wrong the men may be prevented from going down. The only case where an examination is made before the men go to work is on the Monday morning or the day after a holiday, and the *porion* who makes the examination has to leave marks at places in the mine to shew that he has examined them.

In Belgium they do not appear to take any very great pains to fence off condemned working places. In an urgent case a wooden cross is put up before the place, but in general it is thought sufficient that the workmen of a face should be told when they have not to go to it or when they have to leave it. The workmen are not expected to go where they ought not.

In slightly fiery mines it is held that there should be no working in fire-damp. There are, however, some seams where the normal disengagement is so abundant that it would be impossible to work them if it were not admitted that the lamp might shew a cap at the moment of taking down the coals. The Commissioners verified for themselves in a number of these seams that the disengagement was so strong when the coals were being broken down that a blue cap of from $\frac{3}{4}$ of an inch to $1\frac{1}{2}$ inches was shewn at the top of the place and from $\frac{2}{5}$ to $\frac{3}{5}$ at the bottom. In the return, if there are several stalls in activity, the blue cap may be still more pronounced, and, in one of the mines which they visited, their Mueseler lamp, after having shewn more and more, finished by going out at the top of the gallery where a slight fall of roof formed a dead point. They found similar facts

in some perfectly uniform faces, where the stowage was not more than 5 feet from the face, the thickness of the seam 2 feet 7½ inches, and the speed of the air nearly 6½ feet per second.

The Administration recognises that for certain seams it would not be possible to be otherwise, and they reduce to two the number of walls in a section. Sometimes, however, the number of walls is not so much reduced. It must be remarked, however, that the Act of 1850 does not prohibit absolutely the working where the gas shews a blue cap, but only where it shews a "sustained elongation" of the flame. It is pretty generally recognised that so long as the blue cap does not exceed $\frac{2}{5}$ to $\frac{4}{5}$ of an inch, it does not constitute a "sustained elongation." This gas, however, must only be seen while the coal is being taken down and must disappear when this operation is finished, otherwise the district ought to be considered as dangerous and abandoned.

The Commission bear testimony to the excellent discipline of the workmen, and pay a high tribute to their extreme willingness to do anything which may be required of them for the safety of the mine.

In all fiery Belgian mines all the workmen appear to use the Mueseler lamp of a type specified by the Administration.

Many of the superintendents use this also, but the Boty (a kind of Clanny lamp), and Davy lamps are also used, especially by the shot-firers.

It is extremely difficult to find in Belgium examples of mines with mixed lights. In fact, the various seams of a fiery mine are all more or less so; on the other hand legally when a mine is classed as a fiery mine, it is so in all its parts. It would only be in some very slightly fiery mines that from the same crosscut seams would be worked with Mueseler lamps and with Boty lamps or even naked lights. In a case of this kind no special precautions are taken to prevent one kind of lamp from being taken into the places worked with the other. It is left to the workman not to go into a seam with a prohibited lamp. No other precautions are taken even in mines where the drawers use

Boty and the colliers Mueseler lamps. One would not expect to find Boty lamps, and still less naked lights, by a more or less explicit exemption of the Administration in a mine where any quarter whatever would be at all fiery.

All the lamps are provided by the companies, furnished and kept in order by them.

The lamp cabins might vary in the details of their arrangements; they might be more or less commodious or elegant, but they are nearly all made on the same principle. Generally each lamp is numbered, and a number given to each workman after registration in the list. The lamp is given locked to the workman on his presenting a token carrying the same number as the lamp. He gets back this token at night when he gives back his lamp. At Marihaye, where this service is very carefully organised, after a workman has replaced his token, his number is called on giving him his lamp; the workman responds by his name, which is marked off at the same time upon a special register by writing in front the number of the lamp which has been given back to him.

Frequently the lamps are not submitted to any other examination before returning to the workman than that of the lampman. In several mines, however, a superintendent assists at the distribution. At Marihaye there is at the mouth of the pit where the workmen descend a superintendent whose special duty it is to assure himself that all the lamps are locked. In some other mines the bottomer or a special agent of the bottom examines the lamp and verifies, especially by blowing at the foot of the lamp, if it is not frayed. The lamps are everywhere cleaned with a hand-brush to take off the dust, and placed on the coal fire of the lamp cabin to take off the oil, if there is any.

In a very large number of mines they take care to whiten with lime or chalk the lower part of the chimney, situated under the horizontal diaphragm. This small precaution, which has the effect of increasing the lighting power, would deserve to be better known outside of Belgium.

The Commissioners did not see any other lock than that with the screw. They did not appear to trouble themselves in Belgium with more or less skilful or complicated locks. They do not judge them necessary or even useful.

In all the fiery mines of the west of Mons, even in those which are only slightly fiery, and in all those of Charleroi and Liege, which are subject to sudden outbursts, the extinguished lamps can only be re-lighted at the surface. In the slightly fiery mines of Charleroi and Liege, they may be re-lighted at the bottom of the pits the men descend, but nowhere else in the mines. When the lamps are re-lighted at the surface they are sent down in a special carriage, holding 12 or 15 lamps. They are suspended by cords to a ring of stout iron wire, which is fastened to a cross stay on the top of the waggon by a spring. The intervention of this spring seems indispensable to prevent the extinction of the lamps in case of the too sudden landing of the cage on the bottom. Some lighted lamps are kept in store in the bottom, and boys carry the lighted lamps to the face and bring back the extinguished ones. At the mines of Agrappe, where travelling is very laborious and difficult, there are about 150 extinctions per day for 750 workmen. In a neighbouring mine there is an extinction per workman per day.

At Marihaye, workmen specially exposed to have their lamps extinguished have two lamps.

A distinction is drawn in the Act of 1850 between working with powder in the coal and working with it in the rock, which comprehends the brushing of the roads and driving of cross-cuts.

The use of powder for bringing down the coal is altogether exceptional. It only occurs when the seam is not at all fiery. It is true that powder may be dispensed with for taking down the freely fiery seams, and it is observed that the more fiery a seam is the more tender and easily worked is it. It is thus only for the hard and feebly fiery seams that coalmasters have asked and been able to obtain an authorisation, which is never granted but by an Act of the Permanent Deputation.

An authorisation of this kind was granted on the 30th January, 1877, for all the seams of the Colliery of Hasard. The Act remarks, in its preamble, that "several seams of this colliery might give rise under certain circumstances to a disengagement of gas, but that mine possesses two powerful fans, which assure the complete salubrity of the workings."

The authorisation has been granted under the two following conditions:—

1.—In each working place an experienced workman, specially told-off for this duty on the list of control, shall be exclusively charged with lighting the shots, after assuring himself that there is no gas.

2.—No shot shall be fired before the superintendent has made a preliminary inspection of the places.

The coalmasters have interpreted these conditions in this sense that the shotfirer may be a workman of the place and not a superintendent, and that it is sufficient that he has examined the place a more or less long time before the lighting, and has given authorisation to light.

In the other authorisations to work with powder in the coal, which the commissioners heard of, the obligation of a superintending shotfirer (*surveillant boutefeu*) not interested in the work was more clearly indicated.

For the cutting of the roof in very freely fiery seams, the most of the coalmasters seek to dispense with powder as far as possible.

During the cutting of the roof with powder, the workmen are withdrawn so that the lighting of the shots may generally be confided to the *porion* or superintendent of the shaft, who occupies the post of shotfirer. In mines where they use straws, it frequently happens that the *porion* or superintendent is the only person who carries a needle, so that no shot may be charged and lighted without his being there. At all events, he alone ought, after examining the working place, to light the match and give it lighted to the workman who must then light the shot.

For the cross-cuts, some very fiery mines require that the shots should be lighted by the *porion* shotfirer. Generally in this case one of the workmen of the place is specially designated as shotfirer.

At one time the workmen were required on leaving the mine to give up to the superintendent at the surface the powder they had left over. This practice, however, has fallen into disuse, as most of the workmen are able to get the powder for themselves. They generally employ it loose.

In Borinage, straws filled with powder are used nearly exclusively for lighting the shots. The straw is lighted by a

match. At Charleroi and in the centre they employ both the straw and the safety fuse. At Liege they use almost exclusively the safety fuse, which is lighted with a match lighted with a flint and steel.

I have thus given a pretty full abstract of the paper, as I thought it might be more interesting than making it shorter. The report is an exceedingly interesting one, and well worthy of perusal.

MR RONALDSON'S PAPER.

The PRESIDENT introduced the discussion on the paper read at last meeting by Mr J. M. Ronaldson on the "Steam Indicator."

Mr RONALDSON—I find in plate 24, in the section of the Indicator, that the engraver has made a slight mistake. Below the letter C, he has stopped up the orifice leading from the bottom of the piston. Of course, by looking at that, it will be seen to be an error. I only notice one other slight error. It is in plate 28, figure 1. At the bottom "minus 5" should be "minus 5 lbs."

Mr JOHNSTONE—I have not had time to read the paper. Of course, we all know that the use of the Indicator is the only way of getting at the efficient working of an engine. It was invented by Watt, and it is very much the same at present as he left it. It is merely enclosing a figure between certain lines of space, and that space being measured, we can get the working of the engine. The great thing is the proper setting of the slide valve, and by the Indicator we can see if it is right. The economy of the engine depends very much on this. Given a tight piston and good slide valve well set, we have the greatest effect, but given a tight piston and good enough slide valve badly set, and you get very poor economy. The Indicator is a very nice thing, and I think it would be a good thing if every man having to do with engines were able to take a diagram by its means. In that case it would no longer be said "I think it will need a 20 in., an 18 in.—nay, a 24 in." You can see at once what the engine is

doing, and calculate the part to a nicety. A great deal of economy would result from the use of the instrument. Of course, at a coal-pit, where fuel is not of much account, it is of less consequence.

The PRESIDENT—Don't take that view; at a coal-pit, economy of fuel is as important as anywhere else.

Mr JOHNSTONE—I hope the managers will take the matter up and learn to take diagrams for themselves. They will find it to their advantage. It is a pretty thing, and it is something to follow it out and think that actually you can tell the number of the thousands of horse power that may be used. With large marine engines, such as those of the Servia, in a small coil you have a representation of their working; and, I think, any gentleman bringing forward a paper like that should have the thanks of the Institute.

The PRESIDENT—There is a question which has been sent here by Mr BORLAND—"Would Mr Ronaldson inform us if he can give any idea of the quantity of coal burned per HP. while taking these diagrams? as this is the foundation of the whole subject, the knowledge of which would be of the utmost advantage to us in many respects."

Mr RONALDSON—I may say with regard to this point, that about a colliery it is very difficult to do so, because generally so many engines are supplied from the same boilers. Unless you could get a place where the engine you are indicating was supplied by boilers or a boiler for itself, practically this thing can hardly be done. You might simultaneously indicate the whole of the engines, but you could hardly tell what proportion of the coal consumed each was using. In every case where the diagrams given in my paper were taken more than one engine was supplied with steam from the same source.

Mr JOHNSTONE—I may say on that subject, about 10 lbs. of coal per horse power is a very general thing in ordinary land engines where every precaution is in use for saving fuel. The highest perfection we have ever attained in the best compound marine engine is a pound and a half per indicated horse power. That is the very highest that has been attained yet; in fact, before the compound engine came out they were using 3 to 4 lbs.

The PRESIDENT—I quite agree with what Mr Johnstone has so very well put before us, and I am glad that Mr Ronaldson, my colleague, has put it before us so clearly. I am sure that many of you will be delighted with the paper, and also that it will give you some reason for thinking that the Indicator should be much more frequently applied than it is. If we only compare the poor results got from winding engines as compared with marine engines we will see their inferiority. Consider that the "Servia" gives out 10,000 horse power, and that the whole machinery and boilers are in a space 200 feet by 60 feet. If we take an ordinary coal pit winding engine, 18 inch cylinder, at 30 horse power, the "Servia" developes over 300 of these engines, and we know what space this number of engines and their boilers would occupy. This shows us what reform must be made in mining machinery and boilers before we are near marine practice, and the use of the Indicator is a means of enabling us to see these defects. I hope, therefore, this paper will be read, marked, and inwardly digested, and I am sure that you will in the meantime very willingly second my motion that Mr Ronaldson deserves a very hearty vote of thanks for the paper he has given us.

The motion was heartily carried and the discussion closed.

THE ELECTRIC LIGHT AT EARNOCK COLLIERY.

The SECRETARY—Three months ago, I gave some particulars of the life of Swan's Electric Lamps at Earnock Colliery. As stated then the light had been in use for 282 hours, and during that time 11 lamps had given way. The lamps (See Fig. 3) numbered 4, 6, 10, 11, 12, 13, and 14, had all broken once; number 2 twice; and 5 three times. Since giving you the above

particulars, the lamps have given light for 750 hours, or since date of installation 1032 hours, and four of the first lamps put in are still lighted.

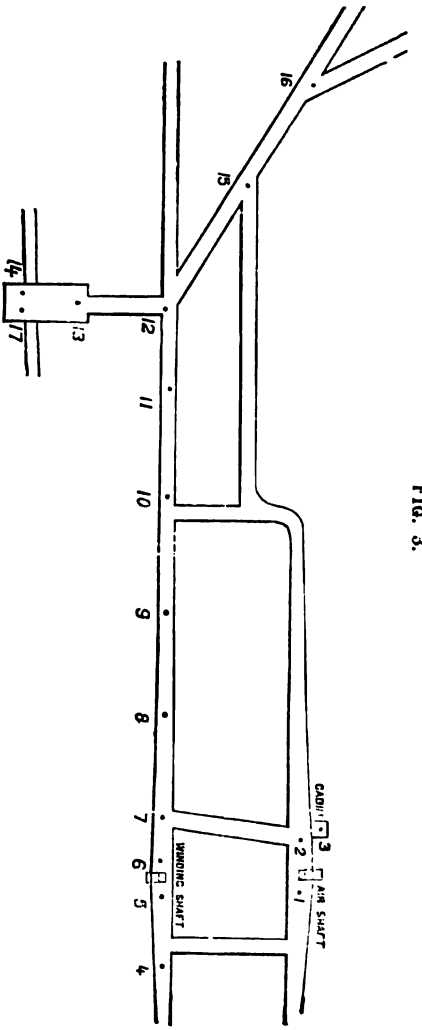


FIG. 3.

The following table will show at a glance the life of every lamp :—

No. of Lamps.	Date put in.	Date of Breaking.	Cause of Renewal.	No. of Hours Lighted
1	August 11	...	Still lighted	1032
2	August 11	August 25	Carbon gave way	112
2^1	August 25	Septem. 10	Carbon gave way	130
2^2	Sep. 10	October 5	Carbon gave way	210
2^3	October 5	...	Still lighted	560
3	August 11	...	Still lighted	1032
4	August 11	Septem. 7	Carbon gave way	230
4^1	Sep. 7	...	Still lighted	800
5	August 11	Septem. 7	Carbon gave way	222
5^1	Sept. 7	Septem. 8	Carbon gave way	10
5^2	Sept. 8	Septem. 13	Carbon gave way	50
5^3	Sept. 13	Septem. 23	Carbon gave way	352
5^4	Sept. 23	Septem. 26	Carbon gave way	20
5^5	Sept. 26	...	Still lighted	640
6	August 11	Septem. 17	Carbon gave way	312
6^1	Sept. 17	Septem. 21	Carbon gave way	30
	Sept. 21	...	Still lighted	680
7	August 11	...	Still lighted	1032
8	August 11	October 11	Carbon gave way	512
8^1	October 11	...	Still lighted	510
9	August 11	Septem. 13	Shifted to replace	No. 5^3
9^1	Sept. 13	...	Still lighted	810
10	August 11	August 25	Carbon gave way	120
10^1	August 25	October 19	Carbon gave way	470
10^2	October 20	...	Still lighted	430
11	August 11	Septem. 7	Carbon gave way	230
11^1	Sept. 7	...	Still lighted	800
12	August 11	Septem. 7	Carbon gave way	230
12^1	Sept. 7	October 10	Removed owing to giving bad light	280
12^2	October 10	October 24	Carbon gave way	120
12^3	October 24	...	Still lighted	280
13	August 11	Septem. 7	Carbon gave way	230
13^1	Sept. 7	October 11	Carbon gave way	290
13^2	October 12	...	Still lighted	500
14	August 11	Septem. 7	Carbon gave way	230
14^1	Sept. 7	...	Still lighted	810
15	August 11	...	Still lighted	1040
16	August 11	Septem. 26	Broken by accident	382
16^1	Sept. 29	Novem. 26	Carbon gave way	500
16^2	Nov. 26	...	Still lighted	110
17	Sept. 30	...	Still lighted	600

No. 9 lamp was shifted to replace No. 5^2 lamp on the 13th September; up to this date it has given light for 272 hours.

No. 5 lamp is near the bottom of the winding shaft, and the men could switch it off and on at pleasure. This may possibly account for the frequent renewals, for since the switch was removed the lamp has not given way.

On the 7th September, through some unknown cause, 6 lamps gave way.

The average life of the broken lamps was about 280 hours, and the life of those still in use about 690 hours.

Three months ago, I said the average candle power of each lamp did not exceed 15 candles. With the assistance of one or two of our members to-day, I tested some of them and found that the light given out only averages 6 candles.

Only one lamp has been broken by accident.

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 12th JAN., 1832,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

RALPH MOORE, Esq., President, in the Chair.

The Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

JAMES HARDIE, Colliery Manager, Benhar, Whitburn, was balloted for, and admitted as an Ordinary Member.

The following gentlemen were nominated for election at the next meeting :—

ROBERT YOUNG, Esq., of Bedlormie.
ROBERT ROBERTSON, Colliery Manager, Bowhouse, Linlithgow.

PATERSON'S INDICATOR.

BY MR JAMES PATERSON.

The PRESIDENT introduced Mr Paterson, Blantyre Collieries, who exhibited his Patent Indicator, and Mr R. T. Moore read the Inventor's remarks on it, which were as follow :—

The bell or signal that is at present in common use is, in my opinion, behind the times, and could be greatly improved upon. Colliery plant in general has been improved considerably of late, but the bell remains nearly the same as it was as far back as I can remember, and is what I would call the word of mouth system. This indicator in question does not do away with the present

style of signalling, but is merely an auxiliary or helper, and is of the same use to the engine-keeper as a memorandum book is to the merchant or tradesman ; it indicates faithfully the number of strokes rapped by the bottomer, whereas without an indicator the mere sound of a hammer or bell dies away gradually, and leaves no register except it be registered on the mind or memory of the engine-keeper. Now, this tax upon the memory is of more importance than many people are aware of, unless they are or have been engine-keepers. The duties of an engine-keeper are many, and a certain amount of responsibility attached to each of them, but watching the bell is paramount to the whole lot, which any honest engine-keeper will readily testify. As it is upon this point that the necessity of an indicator arises, I think it will not be out of place for me to mention a few remarks on this subject. For instance, I knew an engine-keeper who had a most retentive memory for dates in history, who could not with confidence lift the cage if the bell had rapped 30 or 40 seconds before the pithead-man was ready. I have also noticed that a confident man, who seldom makes a mistake, is the most dangerous when he does commit one, and the bottomer may place himself in a very dangerous position by risking to lift a hutch on to the rails of the cage without giving the necessary signal, depending entirely on the fact that this confident man never lifted away the cage without the usual signal being given and is not likely to do so. Also, an anxious man will sometimes run the risk of lifting away when not perfectly sure, rather than be called dilatory or inattentive. As to the reason why intelligent, confident, and anxious engine-keepers will sometimes commit themselves in this particular mistake is a fact that I have no pretentions to explain, unless it happens in this way ; the constant sameness of the sound ringing hundreds of times daily in a man's ear becomes so monotonous that the memory will only retain it for a very short period of time, or becomes dull and confused by the attention being divided between watching the bell and watching the motion of the hutches on the pit head at the same time so as to be ready to lift the cage off the shuts when wanted. Be that as it may, mistakes do occur, with damage to hutches, cages, or slides, and sometimes with loss of life. I remember of an accident happening in the

Old Monkland Parish some years ago wherein the bottomer lost his life. The deceased was supposed to have been in the act of lifting a loaded hutch on to the rails of the cage (which had gone off when hanging on) when the engine-keeper lifted away and the man was crushed at the doorheads. The enginekeeper was apprehended and tried before the Sheriff. He gave evidence that he was signalled, which was corroborated by the pithead-man, and the case could not be proven. Now, I think it is evident that the bottomer did not signal intentionally, and that both the engine-keeper and pithead-man were deluded by some other sound resembling the bell, or a piece of stone or other substance might have fallen down the shaft and struck the bell lever, which might make a signal, but I am certain it would be a peculiar one. I have not the least doubt but the indicator would have proved serviceable in this case, as an imperfect signal will not shift the pointer from zero. I could quote more fatal accidents that have happened to my own knowledge, but I don't think it is necessary, yet I may state that narrow escapes occur almost daily through misunderstandings between the engine-keeper and bottomer—the former declaring he was signalled, the latter declaring he was not. The colliery manager would like to have an indicator put on that would testify who was in the wrong in cases of this sort, and, of course, it is highly desirable, but I am afraid it is an impossibility with the present style of signalling, for this reason, that when an accident takes place it necessitates instant signalling, and often more of it than usual, to get matters put right. I therefore fail to imagine how the offending signal could be traced. The idea of the indicator in question is to prevent accidents altogether happening through misunderstandings or errors of the memory on the part of the engine-keeper, or at least reducing them to the lowest minimum, also doing away to a great extent with the anxiety that exists in the engine-keeper's mind while winding. Its merits are based on the fact that it has been working satisfactorily at Blantyre Colliery for eight years, and is still working, without complaint as far as I know, and any of the engine-keepers who have wrought with it part of that time would gladly testify as to the truth of the above statement. I know of nothing so effective, simple in construction, and easily attached; neither does it

interfere with the laws of the Mines Regulation Act, as it is simply registering the number of strokes laid down for our guidance in the Special Rules. For attaching the indicator to the best advantage, it should be placed almost in (but not intercepting) the view between the engine-keeper and the "shuts" so that he will not require to look to one side, but will see it and the pithead at the same time; also as near the indicator that shows the position of the load in the shaft as may be practicable, so that the disengaging rod may be as short as possible. I may also remark that it can be easily attached to either the vertical or worm and wheel indicators.

Mr PATERSON, in reply to questions, stated that if the engine-man is out, and the signal given he is quite safe to draw the signal bell to the bottom and get another signal. He will depend on the ear for the new signal.

Mr DRINNAN—With an indicator like that, is there any necessity for the bottomer repeating the signal if that works faithfully? If the bottomer signals "one" there is no necessity for repeating it, for it would stand at that. Is the machinery made at all likely to get out of order?

Mr PATERSON—No; there is one at Blantyre which has worked for eight years, and it is as good to-day as when put up.

Mr MALCOLM—Suppose the bottomer hung on his hutch and belled "one"—all was right, and after that something came in the road, and he had to bell "two," how would it act?

Mr PATERSON—It would simply indicate three; but he does not require the aid of the indicator in that respect. The bell sounds the same as now, and he is listening to the bell. It is only in cases where he is not sure of the bell he looks to the indicator for assistance.

The PRESIDENT—I think Mr Paterson has explained his instrument well. I may say I have seen it working at Blantyre, and it works very well indeed, and the engineman seemed to be very well pleased with it. I think we are always indebted to practical men like Mr Paterson for coming forward with their ideas; and I think it right we should give him a vote of thanks for his attendance.

This was cordially agreed to.

EMPLOYERS' LIABILITY ACT.

By Mr JOHN DRINNAN, Arden Colliery, Airdrie.

The subject herein dealt with is something of a departure from the subjects generally read before this Institute, but I do not think it can be other than interesting to those whom its provisions so nearly affect, and, of the interests affected, there seems to me none from whom it more earnestly demands consideration than the mining industries of the country; and my object in bringing it before you is to secure such consideration, believing that we may thereby obtain a fuller knowledge of the responsibilities the Act imposes than we presently possess, which will better enable us to guard our own and our employers' interests from undue suffering through the working of a measure which is believed, by some at least, to be fraught with blessings to what are called the "working classes." I am not one of those who believe that the employing interest will be seriously affected by the working of the Act, nor do I think that Scotch employers generally are so apprehensive of consequences as were their brethren across the Tweed, whose endeavours to contract themselves out of the Act led to such serious rioting and disturbance of the relations existing between them and their workmen; but still it is impossible to read its provisions with respect to compensation for injury without feeling that employers and managers alike have cause for uneasiness, which can only be allayed when we have obtained some authoritative decisions as to the degree of responsibility involved.

Meanwhile, a first-reading of the sub-sections of section I., wherein is defined the liability of employers, is calculated to leave the impression that the profitable working of coal and ironstone must now be a much more doubtful matter than was the case ere employers were made responsible for "any defect in the condition of the ways, workings, machinery, or plant connected with, or used in the business of the employers." We think at once of a possible defect existing in a rope, chain, or other part of the machinery in connection with a colliery, which was not apparent to an ordinary observer; indeed, might hardly be discoverable until

a breakage had taken place. Not less readily does it occur to us that defects in the roadways and working-places of a mine might exist, and not be discoverable without an amount of inspection which would simply mean that the working of coal and ironstone must cease until the decease of the Act, or the demand for coal and iron created a possibility of employers making their assets keep pace with their liabilities.

Reading the sub-sections referred to, however, in connection with sub-sections of section II, we find that employers are not liable unless the defects "arose from, or had not been discovered owing to the negligence of the employer, or some other person to whom he had entrusted the duty of supervision," which practically puts the matter thus:—If, by reason of any of the defects referred to in sub-section I. of section I., an accident occurs, causing injury or loss of life to any one, and it be proved that such accident resulted from negligence on the part of the employer, or anyone to whom he had delegated authority, then the employer must compensate the person injured, or, where loss of life has resulted, the relatives of those so deprived of life.

As it has been in the past, so may we expect the future to be most prolific of that class of accidents which will fall to be dealt with by sub-section I. of section I., and it becomes important, therefore, that we should have a right idea of what will be, and what will not be considered negligence under this Act.

In arriving at a decision on this point, we derive no assistance from the Act itself, it being entirely silent as to what constitutes negligence, and in the absence of information from that quarter, we naturally turn to the Mines Act, wherein the duties of employers and others to whom they have delegated authority are clearly defined, mainly in the General Rules, which are to be observed "so far as is reasonably practicable." If, then, the several workmen whose duties are defined by the General Rules discharge these duties in the way and manner there defined, then I think it could not be maintained that there was that negligence which would entail responsibility under either Act.

In determining, however, whether these duties have been discharged as contemplated by the Act we must have a clear understanding as to the term "reasonably practicable," and, in

arriving at this, we derive assistance not only from the Act itself but from the present practice of inspection as known and approved by Her Majesty's Mines Inspectors.

In General Rule (3), it is provided that *so far as is reasonably practicable*, an inspection of the working places, and roadways leading thereto, is to be made *immediately* before the time for commencing work. Now, those who are responsible for this legislation must either have contemplated a not very minute inspection, or otherwise the employment of a very large army of firemen, or deputies, and, in seeking to elicit what was in the minds of those who legislated on the question, we can have no better guide than the opinion of those to whom has been deputed the duty of enforcing the provisions of the Act—I mean the Mines Inspectors.

Speaking of them as a whole, I do not think it can be said of them that they have been unduly harsh in enforcement of the provisions of the Act, but neither would it be just to say that they are otherwise than mindful of the interests committed to them, and it is within their knowledge that the area or district assigned to each fireman or deputy for inspection is so considerable as to necessitate an ordinarily smart walk, and no very long stay in any one place, in order that his inspection may begin and finish so as to satisfy the requirements of the General Rule which provides that the examination is to be made immediately, or so far as is reasonably practicable immediately before the men commence work.

If this is granted then—and I do not think it can be disputed—then it follows that the reasonably practicable inspection recognised by the Act, and approved by our Mines Inspectors, is such an examination as a man can give going at a moderate walking pace, and if, after such an inspection, an accident should happen, the question which should arise ought not to be—Is it possible that the defect could have been discovered, and the accident prevented by a very minute inspection? but rather—Is it possible that the defect could have existed and not been discovered by the reasonably practicable examination contemplated by the Act, and approved by those whose duty it is to see that its provisions are observed.

What has been said of the inspection of roadways and working places equally well applies to inspection of shafts and machinery, it being evident from General Rule (29), that the framers of it, while seeking to provide the greatest possible security of life and limb to those employed underground were not unmindful that by insisting on too frequent and minute inspections, they might so hinder and interrupt the working of mines as to make them altogether profitless, and we would seriously disparage our own intelligence did we entertain the thought for a moment that those to whom we have entrusted the government of the country should legislate otherwise than for the preservation and better development of what is really one of the most important industries of the country.

In sub-sections 2, 3, and 4 of Section I., the employer is made responsible for negligence on the part of those to whom he has delegated authority, for acts done, or omitted to be done, in obedience to the rules or bye-laws of the employers, and for injuries sustained when acting in obedience to *particular instructions* from a person authorized by the employer to give such instructions. The importance of having right ideas on the question of negligence has been already stated, and negatively the subject has been in some measure dealt with, but it is needful that a positive definition of negligence should be attempted, even though it should serve no other purpose than to form a basis for discussion.

To prove negligence, then, I think that clear proof should be required of a man having failed to discharge a known duty, or of having been aware that a dangerous state of things existed, and failed to report or remedy the said danger. Negligence might also be implied on the part of a person in whose department dangerous defects were found to exist and to be discoverable by a reasonably practicable examination.

But, in connection with this, it should be remembered that differences of opinion may well exist as to what is a dangerous state of things, and if after a rope, roadway, or working-place, has been examined and reported safe, an accident should happen, due to a defect in that which had been declared safe, we are not entitled to assume that there had been negligence on the part of

the examiners, we are not entitled even to assume stupidity ; but even if stupidity were proved, it is not a defect for which employers are liable under the Act. The utmost the Act requires—and any reasonable person would expect—is that employers exercise care in selecting men for positions of trust, where a dereliction of duty would be likely to cause injury or loss of life to their fellow-men ; but even though employers were to insist on all such men having that competency which would enable them to become mine managers, it is not inconceivable that a person so certificated might be unable to determine where safety ends and danger begins.

It may be argued that the latter clause of sub-section 4 of Section I. does make employers liable for stupidity on the part of those in authority, if workmen sustain injury when acting in obedience to *particular instructions* from them, and the argument would have force if the employers were under any necessity to give such *particular instructions ;* but they are not so necessitated, and it is not therefore improbable that, in consideration of the penalty, employers may content themselves, or instruct their managers to content themselves with the issue of general instructions, and leave the workmen to their own care, and that of the Act which their friends have provided for them.

To guard myself against a possible charge of levity in dealing with what is really a most serious matter, I am compelled to express the opinion that the workmen, or their friends, who are responsible for this legislation, made a serious mistake by the introduction of this clause ; nor would I be astonished to find its operation tending to increase, rather than decrease, the number of accidents taking place in mines, as, for the reasons I have indicated, it may not impossibly deprive them of that skilled direction which employers in their own and the workmen's interests have been accustomed to provide.. Should it now be discontinued, workmen would have no just cause of complaint, nor have any right to regard it as other than the natural outcome of their successful appeal to the Legislation to impose a penalty on the giving of such instructions if injury or loss of life result from observing them.

It may be said—indeed, in all likelihood, will be said—that

such action as has been indicated on the part of employers would imply an indifference to human life, if its preservation tended to lessen their profits ; but the charge is no new one, it is (to use a phrase, sometimes heard in this hall) "as old as Time ;" and has not the force it would have had if employers had been as free as heretofore to consult their own feelings as to the amount of protection to be provided for their workmen. Rightly or wrongly, the workmen are in this matter warring against their employers' interests ; in furtherance of their contention, they have, so to speak, appealed to Cæsar, who has given his award, and it would evince a sad lack of manliness on the part of the workmen were they now to complain that employers, in parting with the "pound of flesh," to which the State has declared the workmen entitled, take care that there is not a bleeding accompaniment or even a thousandth part of a grain more than the law has awarded.

Section 3, which defines the amount of compensation to be awarded, seems to me another blunder on the part of those who were attending to the workmen's interests when the bill was under consideration of Parliament.

In said section, it is provided that the sum awarded as compensation must not exceed "the estimated earnings during the three years preceding the injury of a person in the same grade employed during those years in a like employment in the same district." That this will work unequally, and is not at all a fair method of compensation, will at once be seen if we compare the amount that would be payable to a young person just verging on manhood or a young apprentice whose term is nearly finished with the amount payable to a man at almost any other period of his life.

This, however, is a matter for the workmen and their Parliamentary friends to ponder over, and would not have been noticed but for the writer's belief that when the Act's barrenness of those blessings with which it was supposed to be pregnant has been fully demonstrated there will be an immediate demand for its amendment ; and in such a case care should be taken that justice to the working classes is not obtained by the infliction of an injustice on any other class of the community.

The most fitting tribunal to decide on cases arising out of this Act is a question not unlikely to receive consideration in case of

any amendment of the Act, and this Institute would be unworthy of its name if unprepared with a distinct deliverance on a subject so closely affecting the interests of its members and the prosperity of the industry in promotion of which the Institute exists.

It may be assumed that trial by jury will be most popular with the workmen, for what reasons it is unnecessary for us to enquire, but it is worthy of our consideration whether twelve men selected at random from the class to which jurymen belong are so likely to give that intelligent interpretation of the Act which would enable them to decide justly cases arising out of it as highly educated men who have made it the business of their life to fit themselves to administer the law as intended? In deciding this question we have to remember that brains are not necessarily a part of the possessions which entitle a man to sit as a juryman, and I daresay we all know men who are privileged to decide cases having the most important issues, but whose reasoning power or ability to sift evidence, we have never been able to discover.

Even granting, however, that which is most unlikely, that jurymen were all men of average ability, it is not a tribunal to be desired, for the decision of cases where they are called upon to decide, not whether a man has been guilty of a particular act or acts, but rather, that being admitted, is his conduct such as to bring him, or those who are responsible for his actings, within the pale of the law? To arrive at just conclusions on cases of this kind, it is necessary that those sitting in judgment should have thoroughly mastered the scope and purpose of the Act, or Acts, bearing on the question under dispute; it would be absurd to expect jurymen to do this, and the probabilities, therefore, are, that having to decide on a case where a working man, or his relatives, were suing an employer for damages, they would be so puzzled and perplexed by the arguments of opposing counsel as to be unable to come to other conclusion than this, that the law has, or ought to have a leaning in favour of the poor man, and with the knowledge that, however mistaken this verdict, they cannot be made to suffer for it, they would decide for damages, and proportion them, not to the needs of the case or the amount of the culpability proved, but according to the strength of their feelings.

I conclude, therefore, that the most fitting tribunal for such

cases is before a judge or judges who bring to the discharge of their duties minds specially trained for the work they have to do: trained not only in knowledge of law, but trained also to discriminate between argument and mere eloquence; men who, though not devoid of feeling, are ever careful that it does not outrun their reason, and ever conscious that they have a reputation to sustain, which can only be sustained so long as their decisions accord with law and equity.

On the suggestion of the PRESIDENT, the discussion of the Paper was adjourned till next night.

MR LINDSAY GALLOWAY'S PAPER.

The PRESIDENT announced that a telegram had been received from Mr Lindsay Galloway that he was unable to be present. It had accordingly been resolved to forward the written remarks on his paper that had been sent in, and any remarks that might be made by the members present, to Mr Galloway, so that he might write his reply on the whole discussion for publication in the next number of the "Transactions." Taking this view, the President continued, I shall read the following letter which has been sent into the Secretary by

Mr BORLAND—The remarks by Mr Barrowman and other gentlemen are very conclusive so far as they have gone, but the subject still lacks in many important points, such as the best system of recording surveys in the note book. Is the survey reduced to office forms such as is practised by some eminent engineers, or plotted direct on to the colliery plans? The protractor used—whether the Card Board Circular Protractor, such as is generally used on the Government Surveys, or Simpson Patent Protractor, and how is the incline measures reduced to horizontal ones? A description of these by Mr Galloway would tend greatly to augment the value of this paper, and would be edifying to many of the members.

The PRESIDENT—That is a point rather foreign to Mr Galloway's paper. There was another note from

Mr HUGH JOHNSTONE—With reference to the very common

idea that if a compass be placed exactly mid-way between the rails of a tramway, the attraction of one rail will neutralize that of the other, Mr Galloway states that this is true only in certain positions. He might have added "and in certain circumstances." Even in the case of rails lying exactly parallel with, or at right angles to the meridian, the needle will be undisturbed only if the polarity of the rails is similar. If a road has been recently laid, more especially if steel rails have been used, it is possible that they may have an opposite polarity, in which case the deflection of the needle due to one rail will be doubled by that due to the other. This may be carrying theory too far for ordinary underground surveying, but may serve to shew that it is unsafe to trust too much to the fact that a road is lying north and south, or east and west. As shewing the advantage to be derived from using a high tripod when surveying over steel or malleable iron rails, I may mention that it has been proved by Gauss that "when the distance between the centres of two magnets is large compared with the size of the magnets, their action on each other varies inversely as the cube of the distance." The high tripod being usually double the length of the low one, its use therefore reduces the attraction due to rails to an eighth of what it would be with the other. Mr Galloway's arrangement for quickly and securely attaching the compass to its stand is highly ingenious. He will find it an advantage to hang the light *under* the stand, as the plumb is hung under the theodolite, instead of setting it upon it. This renders it impossible for the attendant to hold it off the plumb, and also obviates the necessity for removing the light in order to fix the compass. Some reference is made in the discussion as to the North of England system of transferring a base line from the pit bottom to the surface, or *vice versa*. Might I ask Mr Galloway if he has seen this done, and if so what precautions are taken to prevent the sight being obscured or obstructed by water falling down the shaft upon the transit instruments; or if sighted from the surface downwards, what arrangement is adopted to protect the instrument from the vibration due to the machinery?

Mr BARROWMAN—With reference to the remarks of Mr Borland, my impression is it would have been valuable if Mr

Galloway had supplemented his paper with remarks on that matter—but that is a different subject—it is not surveying. With reference to the light suggested, unless the tripod is standing on a level piece of ground, hanging the light below is not exactly to have it under the centre of the instrument. I think the practice of keeping as far back from iron as possible is the safest way.

The PRESIDENT—But how far?—that is the point. I think there is a good deal in what he says as to the polarity.

The discussion was then closed except as regards Mr Galloway's reply, which is as follows:—

Mr GALLOWAY—Several members have referred to the methods in use for connecting a surface and an underground survey. The convenience of the magnetic needle for this purpose cannot be denied, and, I believe, that when due precautions are taken to remove all iron from the neighbourhood of the compass, considerable reliance may be placed upon the result. We know that there are certain small daily variations of the needle, and that the position of the point of the needle cannot be read off with the same minute accuracy as a vernier; yet, on the other hand, any error arising from these causes cannot exceed a very small quantity, and the simplicity of the method is greatly in its favour. As regards the distance to which rails and other attracting masses should be removed, the remarks of Mr Johnston illustrate the fact that the attraction of a small mass of iron becomes comparatively trifling when it is removed to a short distance from the compass. Of course a large mass, such as a column of pipes or an engine, would produce a great effect upon the needle even at some distance; but I think rails will be found to produce no appreciable effect if removed to a distance of from two to four yards on each side of the compass. I would not, however, place any reliance upon a bearing taken without the rails being lifted, even if a high tripod was used, for in conducting a survey by angles, there is an opportunity of noticing the effect produced by rails underneath the instrument, and the needle will sometimes be seen to be deflected as much as 10° or 12° from its true position.

I have frequently used the method of hanging plumb lines down

two or more shafts and surveying between them so as to connect the surface and underground plans without the use of the needle, but I have not tried any of the other methods alluded to in the paper and enumerated by Mr R. T. Moore. A description of the use of the transit instrument for this purpose is to be found in the Transactions of the North of England Institute of Engineers. In the method where two plumb lines are suspended in the same shaft, it is a question how far the lines might be made to deviate from the vertical by a current of air, even supposing the plummets to be immersed in buckets of water. Might not the ventilating current blow upon the lines and cause them to deviate to such an extent as to give rise to errors? Perhaps, however, this source of error might be removed by using fine wire for the lines, with very heavy plummets attached.

It is satisfactory to hear from the President that the reference of all levels to a fixed datum below the sea level and marking them in figures upon the plan is a system which he highly approves of, and that it is in use at some of the larger collieries.

There are several points which I would gladly have referred to, and among them those mentioned by Mr Borland, such as the plotting of surveys upon the plan, whether by protractor or by co-ordinates, the measurement of areas, the determination of true north, the setting out of curves, whether above or below ground, and also the various kinds of surface surveys. These subjects, however, could hardly be introduced at this stage of the discussion, but I hope that some other member of the Institute may favour us with his views regarding these and other points before long.

MR R. T. MOORE'S PAPER.

The PRESIDENT then invited criticism on Mr R. T. Moore's paper in relation to Belgian mines.

Mr MACCREATH—This is a very valuable paper, and the way in which the French engineers' report has been translated and condensed is creditable in the highest degree to the author of the

paper. (Applause). Even the labour that must have been required for the conversion of the French measures into English measures must have been very great. It has a peculiar interest, I think, from being the report of French engineers—the most competent engineers that could be got in France—inspecting the workings of another country ; and in both of those countries scientific knowledge on the part of those conducting mining operations has been more imperative hitherto than it has been in this country. In looking over the paper, there appeared to me to be many things which those conducting mining operations in this country might under modifications copy. There are a few things, I think, it would not be well to imitate here. One of those is the using of hand-driven fans instead of brattice for the ventilation of fast places. These hand-driven fans were much more in use here thirty years ago than they are now ; and, so far as their use came under my observation, I think they were very seldom driven unless there had been an accumulation greater or smaller of fire-damp, or unless the air at the face had become so foul that those working could tolerate it no longer. One of them then went out and cleared the place of foul air and resumed working again. Of course, the place became very soon after foul, and the same operation was repeated. It was also the cause of many explosions by driving the fire-damp out on the naked light. I think we can see also in this report the evils of over-legislation. Impracticable laws are made, and consequently those on whom they ought to be binding wilfully misread them, and those whose duty it is to see the laws put in execution are obliged to acquiesce because it is quite impracticable to carry out the act in its entirety —a state of matters, I should imagine, very demoralising for those who should obey the law and those who should see it enforced. In a foot-note, the author of the paper introduces to us something new—that is, the equivalent orifice. I am not quite sure if I understand fully what information this term gives us, and I would ask if it conveys any more information than a statement would do which said that the equivalent current at one inch water-gauge would be so many cubic feet. Take, for instance, one of the fans in the table, you will find that one of them produces a current in the pit of 28,800 cubic feet with a water-gauge

of 1·21, and that the equivalent orifice is 10 feet. Does that convey any more information than if you said that this current and water-gauge is equivalent to a current of 26,182 cubic feet at 1 inch water-gauge? Perhaps the author or some of the other members present who are acquainted with the French engineers' writings might also explain what is the reason that they use the formula mentioned there for the theoretical power of the fan.

Mr R. T. MOORE—The notion of equivalent orifice mentioned by Mr MacCreath is only mentioned as being rather a neat way of expressing the resistance of the mine, and although it does not express any more than saying that the mine is such that a certain quantity of air would pass through it in a given time with a given water-gauge, it is perhaps a shorter way of saying so. I have not noticed it before in any English writings on the subject. There is a proof of the formula, given for calculating the water-gauge produced by a centrifugal fan, in an article by M. Murgue, which appeared in the "Bulletin de la Société de l'Industrie minérale," vol. IX., 1880, pp. 5-101. This paper has been translated and abstracted for the Institution of Civil Engineers (vol. LXVI., session 1880-81, part IX.), by Mr Alfred Bache, M.A., Assoc. Inst. C.E.

Mr RONALDSON—I notice at top of p. 254 the remark:—"The fan" (reads). I am curious to know why the fan should be placed as far as 100 yards from the upcast: do the Commissioners give any reason for that?

Mr R. T. MOORE—There is no reason given. It is merely stated as an instance in which the fan is some distance from the upcast shaft.

Mr DRINNAN—There seems to me an apparent inconsistency at p. 251, near the top—"These exemptions" (reads); and, lower down, "There is" (reads). I was anxious to know which of these was the correct one.

Mr R. T. MOORE—Although there is no legal difference between the slightly fiery and very fiery mines, still, in granting exemptions there is a difference made. Those subject to sudden outbursts are carried on very much more stringently than those which are less fiery, and fewer exemptions are granted to them.

The SECRETARY—Referring to the table at p. 265, would Mr

Moore explain it more fully, for, according to the way I read it, the figures given in columns 3, 4, and 6, the quantity of air per man is not correctly given in columns 7 and 8. If the figures in the first columns mentioned are correct, the quantity of air per collier, as given at foot of table, should be 7336 c. ft., and per workman 2838 c. ft., instead of 445 and 172 c. ft.

Mr R. T. MOORE—The quantities in column 6 have unfortunately been given in cubic feet per second, while those in columns 7 and 8 are given in cubic feet per minute, and a comma has been put in instead of a decimal point. Thus 41,936 should be 41·936 per cubic feet per second. This is the cause of the apparent discrepancy.

Mr RONALDSON—Might I ask who the engineer-in-chief is?

Mr R. T. MOORE—The service of mines in Belgium comprises two divisions—one at Mons for the Province of Hainault, the other at Liège for the Provinces of Namur and Liège. At the head of each of these divisions is an engineer-in-chief who reports to the Permanent Deputation of Provincial Council.

Mr BARROWMAN—I have not had an opportunity of reading the paper, but last night when I heard it I was at a loss to understand who the Permanent Deputation were.

Mr R. T. MOORE—The Permanent Deputation appears to be a committee of the "Provincial Council" which is an elective body administering the local affairs of each province.

The PRESIDENT, in adjourning the discussion on the paper, hoped that in the interval members would study the paper carefully and especially the tables. It contained a very great amount of information, some of which might be useful to them, and all of it worthy of discussion. He especially hoped that those who were unable to attend the meetings would send their remarks to the Secretary, so that full justice might be done to the subject, and any errors in the translation rectified. He especially called attention to the depth of the pits, and the quantities of air for the men employed.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 9th FEB., 1882,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

RALPH MOORE, Esq., President, in the Chair.

The Secretary read the Minutes of the last General and Council Meetings, which were approved of, and signed by the President.

The following gentlemen were balloted for and admitted as Ordinary Members:—

ROBERT YOUNG, Esq., Coalmaster, 37 West George Street, Glasgow.
ROBERT ROBERTSON, Colliery Manager, Bowhouse, by Linlithgow.

The following were nominated for election at next meeting:—

WILLIAM FERRIE, Esq., Monkland Iron Works, Airdrie.
ANDREW WINNING, Overseman, New Farme Colliery, Rutherglen.

HAULAGE EXPERIENCE:

BY MR JONATHAN HISLOP, KINNEIL IRON WORKS, BO'NESS.

[Owing to the unavoidable absence of Mr HYSLOP, the Paper was read by Mr W. LAWSON, one of his Assistants, who afterwards took part in the discussion.]

WHEN invited by the Secretary, some months ago, to contribute a paper to the proceedings of this Institute, I had every inclination to comply, in order to shew my appreciation of its usefulness, and to do some small share of its work; but it was

not clear to me that I could say anything that had not been very well said already by other members, and read by me with great interest at home.

It occurred to me, however, that as any record of actual facts is always more or less useful to others in a similar line of life, I might note down a few things in reference to surface and underground haulage, a subject in which I have taken a great interest for a long time. Having already in "Colliery Management" written considerably on this subject, I do not think it advisable to go over the same ground, but rather to add as a sequel the experience of later years.

Speaking then from this standpoint, I find it requisite in adopting any system of conveying mineral, to aim at the following qualities:

1. *Simplicity*, so that uneducated men and boys may easily understand, and deal with it, and that repairs and renewals may be few and readily accomplished. The best machinery, and most effective contrivances, are eminent for simplicity, and anything elaborate or complicated, is quite unsuitable for pit work. So far as I can judge, mechanical engineers too often forget that by and by breakages will occur, and fail to provide adequately for such a contingency. I have had much trouble, expense, and loss of time owing to this, which might very easily have been prevented by a little intelligent forethought.

2. *Safety*, in order that the limbs and lives of our people may not be unnecessarily endangered. Unfortunately, we cannot make any arrangement which will be absolutely safe in all circumstances, and especially to men and boys who too often neglect the simplest precautions. But we should so plan, that in the sad circumstance of an accident occurring, we shall not have to reproach ourselves for manifest omissions. To help us in this, we have a record of every kind of accident in the annual reports of the mine inspectors, and thus may get valuable suggestions from the misfortunes of others.

3. *Suitability*, so that the special requirements of each individual case may be properly met. No two collieries are exactly alike, and hence a very good plan for one is not necessarily so for another. Many very serious mistakes have been

made through not realising this, and we all require to guard against carrying favourite notions too far. Otherwise, many a good idea is made to suffer for an injudicious application of it. I remember visiting, some years ago, an old but valuable English colliery where they had resolved to adopt the endless chain. The manager was a clever engineer, and seeing the system working so well in another locality, became enamoured of it. He put up the very best hauling machinery; cut a double road straight as an arrow through 1200 yards of old pillars and waste, and furnished it with nearly 3000 yards of long linked ¾in. chain, intending it to last for 12 or 15 years. But it was a dead failure; and why? Because the expense of keeping up the roads through the old waste far outweighed all the advantage to be obtained from it, and the whole had to be thrown out for little better than old material. The system was good in itself, but quite unsuitable in the circumstances. About the same time, quite an opposite case occurred in Scotland. An owner had sunk upon a new field, and we both agreed that for a good pit, with a large output, there is nothing equal, as a general rule, to a locomotive line and sidings, for comfort and ease in working, but in this case very soft ground must be crossed for near three-quarters of a mile, new rails, chairs, and sleepers must be got for it, and after all, the field was uncertain in extent. He therefore fixed upon an endless chain, which did not require half the money, used up a lot of old material to good purpose, worked well and cheaply, and when, four or five years after, the field became exhausted, saved him the loss and mortification consequent on valuable plant rendered useless.

4. *Adaptability*, so that the system employed may be effective in other circumstances that may arise, and probably will arise, as time goes on. We require to consider what will be the effect of changes in the roof or pavement, alterations in the dip and rise, and possible dislocations in the seam itself. Not only this; but how will the plan answer when the working faces are far advanced, and probably in different ratios, in every direction? Thus in one of our Kinneil Pits, we have a very fair sample of an endless rope, working a dook in the usual way; but because there is no provision for following the faces, it is left far behind, and men and

horses have to be employed for what the engine has ample power to do, but cannot reach. In another pit, we have a dook, worked by a single rope from the surface, to a point 1200 yards inbye. Hutches are put upon a carriage running on permanent rails of broad gauge, and it is drawn up with speed and safety; but there it is, a fixed engine, and now when the faces are far extended, a new system is urgently required to secure economy.

5. *Efficiency* again is essential, so that not only a present moderate output, but a possible large one may be promptly dealt with. We want plans that will not break down when a hurry comes; but rather will pay best when hard pressed. In employing horses, for instance, my experience is that the more of them the less work done per head; and hence they are only efficient within a very limited range, or in very special circumstances: whereas a really good system will produce the very opposite results.

6. *Economy.*—This, after safety, is the main object in any system. No matter how ingenious the arrangement or how gratifying to visitors, if it won't pay it won't do. The capital required to start it, and the additional capital to extend it, require careful consideration, for once spent there is ever after a serious charge for interest and depreciation. On the other hand, it is not true economy to save capital at the expense of greatly enhanced working costs, although it is sometimes no easy matter to decide which way the balance turns, how much to do and how much to leave undone. This much is plain, that many Collieries are unprofitable that might be otherwise by a judicious expenditure on modern improvements, and it is equally clear that many others are borne down by capital charges recklessly or inconsiderately brought on. And because of this, very varied intelligence, sound judgment, extensive experience, and unwearying industry, are qualities much needed by every manager.

In endeavouring to secure these qualities of simplicity, safety, suitability, adaptability, efficiency, and economy, or as much of them as possible in my own practice, I have naturally met with many difficulties, have had many things to learn, and some to unlearn; but, notwithstanding inevitable mistakes, the general

results have been very encouraging in accomplishing work and reducing costs. During the past fifteen years, I have tried the single rope, tail rope, endless rope, and endless chain, and the conclusion I have come to is that for general purposes about a mine the last is the cheapest and best, and hence I would only fall back upon another plan when the chain had been tried and failed or was evidently unsuitable.

At Cobinshaw, where it was applied in 1870-71, my only guide was the report of the Newcastle Tail-rope committee, there being at that time, so far as I am aware, no endless chain working in Scotland ; but in spite of the drawbacks incident to such a start, and that the appliances were by no means first-class, the results were so good that I was much impressed in favour of the system. Gradually there and at Shotts we had 4000 yards running, which for many years did much hard work with little trouble and very cheaply.

At Kinneil, in 1878, I found the traffic worked by means of incline engines and many horses. Small waggons carrying 2½ to 3 tons were thus drawn over some miles of light railway, of ordinary gauge, much too light for the heavy trucks and heavier loads of modern times. The whole had been well arranged at first, and had done an enormous amount of work ; but the world has gone far forward in thirty-five years, and many a good old plan is excessively expensive and tedious now.

A survey for a new locomotive railway revealed gradients no better than 1 in 17 and 21 for a long distance, and, although engines have worked and are working gradients steeper than these, I was advised by locomotive engineers themselves to abandon the idea, on the score of extra expense and increased danger.

In these circumstances, it was natural to turn to the system that had served me so well for seven previous years, and the more I thought of it the clearer my course became—to try the endless chain at Kinneil. It promised to enable us :—

1. To form the necessary roads at comparatively little expense, and to use up profitably some miles of worn 30-lb. rails, chairs, and spikes which, being much too light for ordinary traffic, would have to be sold for what they would bring.

2. To employ an engine for haulage already in position, and which I anticipated would be driven by the steam raised from waste heat at the coke ovens.

3. To get considerable advantage from the very gradients that were fatal to a locomotive line, and so cheapen the costs of working.

4. To arrange that all the weighing of incoming and outgoing mineral could be done at one spot, and so secure that concentration which is always favourable to economy.

5. To have one principal screening station near the main line, which would answer for all the pits, to any extent, and for any time.

6. To empty all the minerals required for the furnaces from hutches, at considerable less cost than could be done from ordinary trucks in the usual way.

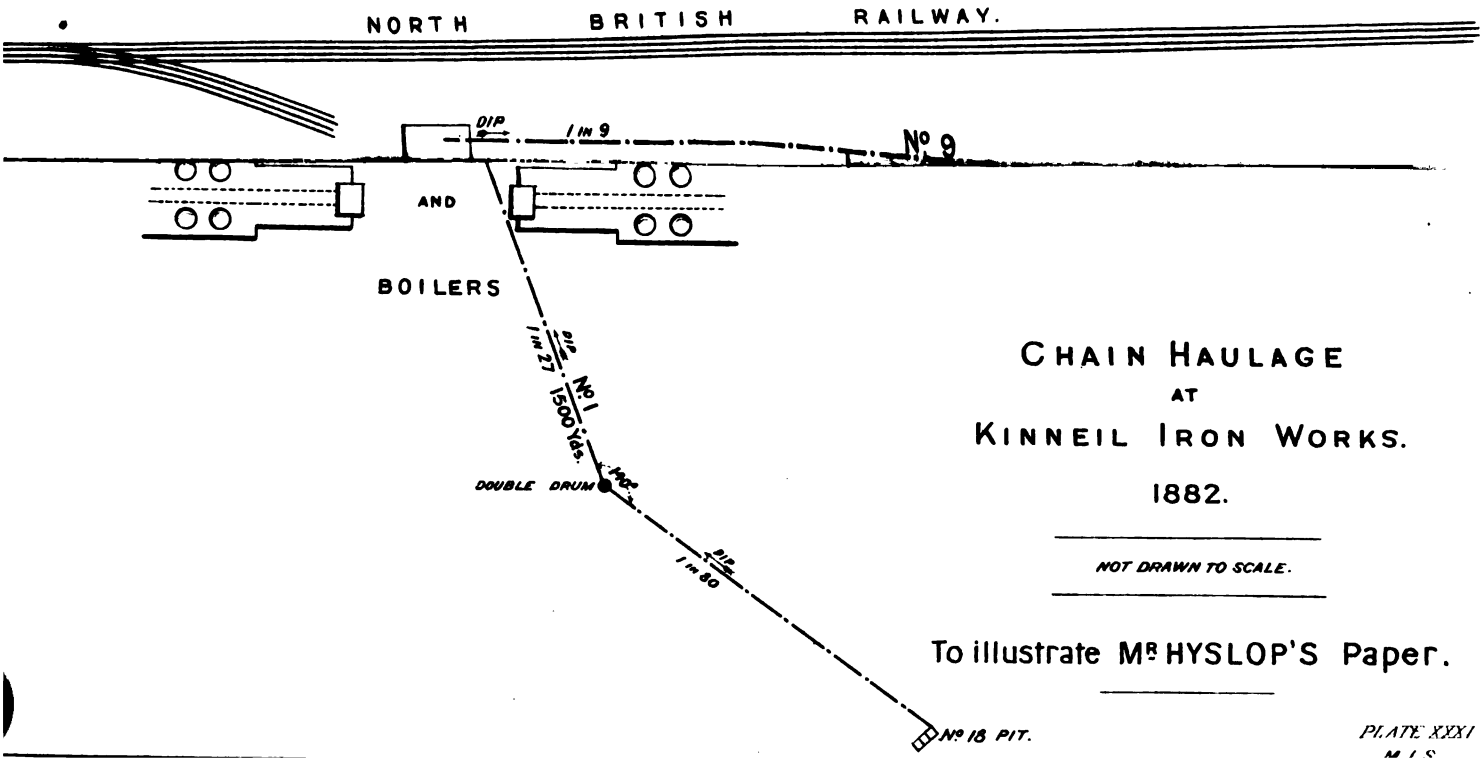
7. To have uniformity of system and traffic above and below, so that different minerals could be sent indifferently in any direction, either on the surface or underground, with a minimum of labour and cost. And

8. So far as I could judge, the whole traffic could be worked and upheld at less tonnage cost and with more safety than by any other system of haulage with which I was acquainted.

These prospective advantages secured the cordial sanction of the Directors to the plans; and I'm very glad to say that our expectations have not been disappointed.

As you will see from the accompanying diagram, the principal chains radiate from one point. The hauling engine is horizontal, having 18-inch cylinder, and 3½-feet stroke, geared 3 to 1, and usually driven so that the chains go from 1½ to 2 miles an hour, with steam pressure ranging from 35 to 40 lbs. The old incline drum is still retained and can be used on occasion. The chain gearing is under the floor and drives upright shafts on which the chain drums are fixed and fitted with clutches, so that any one can be at once stopped. These drums are 3½ feet in diameter, of cast-iron, and made conical on the under side to allow the chain to slip, which usually has 2½ turns round each drum, and only in *two* cases are back balances used to secure driving friction.

All the roads are laid with old 30-lb. rails to a gauge of 31½ inches, on through sleepers about 5 feet apart. The distance



CHAIN HAULAGE
AT
KINNEIL IRON WORKS.
1882.

NOT DRAWN TO SCALE.

To illustrate Mr HYSLOP'S Paper.

PLATE XXXI
M I S

between the roads is 12 inches, and they are all furnished with hollow cast-iron rollers. The weight of roller and bracket is 30 lbs., and the cost 1s 8d. Their average distance apart is only 5 yards, owing to the fact that most of our chains have to run a good deal empty.

The hutches are of the ordinary close-ended type, made to suit our size of shafts and seams, and carry from 5½ to 11 cwts., according to the nature of the mineral. The edge wheels are 10 inches in diameter, cast on the axles, and of cast iron, as we make our own. The chain is attached by a fork at one end in the usual way, and all greasing is done by means of M'Pherson's machines, which are very simple and effective.

No. 1 *Chain Road* brings all coking and furnace coal (see Plan XXXI.), as well as char, from No. 18 Pit to the hauling engine where it is screened, crushed, washed, and distributed as may be required. Its length is 1500 yards, the upper half having a fall of 1 in 80, and the lower 1 in 27 towards the engine, so that when full it almost works itself. We were obliged to put a bend near the middle which costs us 3s a day to work, as both chains leave the hutches, but advantage is taken of it to divide the chain into two lengths, by means of two drums, the lower driving the upper, and in this way a great deal of strain is taken off the upper end. The man is also able to over-see the road for a long distance each way, to keep a level crossing, and at once to signal any defect or stoppage. The usual work of this road is 200 tons a day, but it will be greatly increased.

No. 2 is only 70 yards in length, rising 1 in 20 towards the engine, and is employed in bringing coal and redd from Snab Pit.

No. 3, which is 150 yards in length, lifts all the char from the hearths of the same pit and is level.

No. 4 falls for half its distance at the rate of 1 in 8 towards the screening house, after which it rises 1 in 25 and is carried overhead across the yard. Its length is 350 yards, and it carries down all minerals for sale or use about the shops and brickwork, bringing back at the same time char, coal, limestone, &c., for the furnaces. In the screening house it passes round a drum on a horizontal shaft and thereby drives

No. 5, which is 45 yards in length, with a rise towards the drum of 1 in 6, its work being to carry all bought-in mineral, &c., to the other chains for use in the furnaces. A second small drum on the same shaft is intended by and by to carry redd across the N.B. Railway into the sea.

No. 6, which is 150 yards long, is used for conveying redd from Snab Pit, and coal washings, &c., from the coke ovens to the tip head.

No. 7 is 250 yards long to the furnace hoppers, whither it carries all the char, coke, coal, and limestone required. It falls towards the hoppers at the rate of 1 in 75.

No. 8 passes along to No. 24 Pit, a distance of 340 yards, is nearly level, and brings back coal and char. A sharp bend near the pit is self-acting, the full hutches keeping the chain, but the empty ones requiring a striking-out pulley and sufficient fall to make them run through and catch the chain on the lower side.

There are thus eight chains presently worked by the central engine, all the traffic being weighed near it and controlled by electric signals from the weighman's box.

No. 9 is driven in passing by the mechanic's engine, and is 400 yards long from the screening house to the brickwork, whither it carries coal and mine dust, bringing back brick, fire-clay, and mortar to be distributed as required. We are thus able to load bricks, &c., in the kilns and send them direct down the pits without transhipment.

No. 10, driven by the brickwork engine, is elevated about 20 feet above the ground for a length of 150 yards, and is employed in bringing material from No. 24 Pit for brickmaking.

Finally, No. 11 is in course of construction from No. 24 to Schoolyard Pit, a distance of 1200 yards. It has considerable curves, and is carried for a long distance on lattice-work bridges, but the gradients are very easy. It is intended to be driven by No. 8 chain, and will bring in gas coal, house coal, ironstone, &c., from Schoolyard Pit to the works, which hitherto has all been done by cartage.

We have thus ten chain roads in active operation, embracing a length of 3400 yards, and requiring 7000 yards of chain, weigh-

ing 20 tons, all of which is kept running ten hours a day and six days a week, with few stoppages and very little trouble. This ere long will be increased to 9500 yards.

It is only fair to note, however, that these chains are all on the surface, and consequently have a much better chance than similar ones underground, of which, as yet, I have had no experience; but we are preparing for them extensively in Snab Pit, so that by and by their merits will be tested there.

It is proper also to state that amid many successes we have had one partial failure. On the suggestion of a visitor, I tried a chain on our furnace hoist, which is about 180 feet in length, and rises 1 in 3 and 4, but we found great difficulty in getting the men to be careful in attaching the hutches, especially at night, and also increased trouble in emptying them into the furnaces as compared with barrows. I felt, therefore, that in the hands of the men it was not sufficiently safe and economical, and in a few weeks changed it for a wire-rope, carriage, and barrows in the ordinary way.

These chains have all come into operation within the past nineteen months, and the actual work done over the whole time is 200,000 tons, but two or three times the amount could have been carried with equal ease.

The *size* of chain we use is $\frac{7}{16}$in. diameter, short link, tested, and of the very best quality, in proof of which we have only had one broken chain the whole time except at false links we ourselves had put in.

The first *cost* of the whole length was a little over £330, which is exceptionally low, owing to the fact that we got a large quantity at considerably reduced price, because it had been some time in use.

The *wear* of the chains is increased in our case by the fact that we require to run them continuously to suit our traffic, and consequently they are very often underladen and running empty on the rollers which, as already stated, are planted thickly on this account. But it is cheaper for us to allow this extra wear and strain than to employ people to keep them full with additional empty hutches.

Notwithstanding this drawback, the perceptible wear is very

small for the time, and we may safely calculate on their being good for 400,000 tons yet, which will give 1800 tons for every £1 of original cost.

Indeed, it is one of the advantages of a uniform and extensive system of chains that they can be worn entirely away by gradually changing them to shorter lengths with light loads. Thus a piece unfit for anything else, has drawn not less than 7000 tons to our brickwork, and is running still. In the same way, at Shotts, a length of inferior quality, and considerably worn, has drawn several thousands of tons up an incline of 1 in 12 during the past seven years, and although it has been idle and exposed to the weather at least half that time, it is in use still.

In contrast to this, and in answer to the question very often put—Why do you prefer chains to ropes? I may mention the results of my experience with the latter:—

1. On the same incline at Shotts, when worked with single and tail rope we used up two in two years, at a cost of £60. One was of charcoal wire, and the other of best steel.

2. When we took the endless chain off the furnace hoist at Kinneil, we put on a steel rope, costing £9 10s, which only lasted six weeks. We replaced it with another costing £9, and it did no better. We then put on a third, and though of smaller size, and already somewhat worn—such is the difference in quality—it has drawn over 58,000 tons, and apparently is little worse after eight months' running night and day.

3. Our Snab endless rope is 1300 yards in length, and it has been twice worn out in the past 26 months, at a cost of £148 for rope alone, to which must be added expense of splicing, and loss consequent on the pit having been thrown idle on several occasions. During that period it has drawn 81,000 tons to the shaft, or 550 tons per £1 of its price, as compared with 1800 tons by the chains. The distance drawn by the rope is 600 yards, and consequently its work has been equal to 27,600 tons drawn one mile for £148, or 18,650 tons per £100 of amount paid for it.

In contrast to this the following is the work of the chains:—As already stated, 3900 yards were bought at a reduced rate because it had been used. On inquiry I find that 2600 yards had

first run four years on a road 1200 yards long with a load on it averaging 17 tons of coal, and it had drawn a total there of 261,000 tons in that time. Sufficient new chain was then added to it and the whole put on another road 1900 yards long where it drew 15,000 tons more. Most of it had therefore worked five years ere we got it, and the whole work done in that time was 194,000 tons drawn one mile.

To this was added 3100 yards of new chain at Kinneil, and the whole length has drawn 200,000 tons there, an average distance of 888 yards, equivalent to 100,000 tons one mile. As previously stated, the price to us was £330, so we have got 30,300 tons conveyed a mile for each £100, and they are good yet for 60,000 tons more.

It is at once admitted that this comparison is not quite fair to the rope, because the conditions are not equal, but the difference in favour of the chains between 18,670 and 90,000 is much too great to be explained either by the nature of the ways or the work done.

There can be no question as to the great value of wire ropes for many purposes and in many situations about a mine, but they are so uncertain in wear and tedious to repair—so easily injured and of so little value afterwards—that for these reasons I decidedly prefer chains wherever they can be properly applied.

Adding together the separate quantities drawn by each of those at Kinneil, the average day's work is now 750 tons; but inasmuch as most of the traffic passes over more than one, the quantity delivered and emptied is 500 tons per day, this being the average over a long period.

It is evident that with so many chains in constant motion, furnished with men and only this tonnage, we cannot attain the high standard of economy per ton per mile that some have reached: as, for instance, some of the cases given in the report of the North of England Committee where quantities nearly equal to ours are carried along one chain road of great length.

The wages paid are mostly at each end and, consequently, very much depends on mere length for reducing the tonnage cost per mile.

At Kinneil the day's work is naturally very variable, but as near as may be the average is as follows :—

20	Tons	Lead	1750	Yards—	35,000
180	„	„	1500	„	—270,000
10	„	„	870	„	— 8,700
90	„	„	650	„	— 58,500
10	„	„	600	„	— 6,000
30	„	„	590	„	— 17,700
60	„	„	400	„	— 24,000
60	„	„	250	„	— 15,000
40	„	„	225	„	— 9,000
500					443,900

Which gives an average distance of 888 yards, or almost exactly half a mile.

The influence of length is shewn by the fact that the first 200 tons for 1500 yards only cost 12s per day for wages, or something like a penny per ton per mile, while another 220 yards in length costs 8s for 50 tons, equivalent to 1s 3d per ton per mile.

On looking over the accounts for a considerable period, I find that the average cost in wages for engineman, chainmen, weighman, emptying, greasing, and repairs of roads and rolling stock with stores and furnishings added, is 83s per day for the whole work done. This for 500 tons is practically 2d per ton for 888 yards, or 4d per ton per mile, thus divided :—1½d per ton for leading, 1½d for emptying, and 1d for furnishings and repairs.

In the accounts of the Tail-rope Committee, the average of 6 collieries leading 323 tons per day is given at only 1·379 per ton per mile, but I am not sure that the cost of emptying is included.

On the other hand, the report *does* include the cost of fuel for driving—an item which we are almost entirely saved, for, with the exception of 300 yards, all our chains are driven by waste heat from the coke ovens and furnaces.

There is nothing included in the 4d per ton per mile for interest and depreciation, though, so far as I know, all other expenses are included. But against this no credit is taken for saving in handling bricks, nor for ¾d per ton saved on all char filled. This lessened rate for char is due to the fact that it is much

easier to run a hutch and attach it to a chain than to wheel a heavy barrow up a steep plank to be tipped into a truck, and is worth in our case £100 a year.

In all this there is no pretence to originality or infallibility or to the communication of new truths. It is meant simply as an account of well-known ideas applied to new circumstances, and the success that has followed the experiment.

The PRESIDENT—This paper will be before you for discussion another evening, and I daresay you will have material enough for reflection upon it.

Mr ANDERSON—Do the same hutches that run on the surface go down the pit ?

Mr LAWSON—They go down one pit just now, and will go down all the others by and by.

The PRESIDENT—I think in some of your underground haulages you contrive that they run from the one chain on to the other without change.

Mr DIXON—I have seen that done at any rate.

Mr LAWSON—It does that at some points.

Mr DIXON—It is a general thing that it requires some one to manage them.

Mr LAWSON—You require to send it to No. 3 to be screened.

Mr D. SIMPSON—What kind of catches are used for the hutches along the roadway ?

Mr LAWSON—The usual catches. They are a fixture on the centre of the hutch, sometimes at the back and sometimes the front. It generally pulls.

The PRESIDENT—Some people prefer to have the catch behind the full load.

Mr LAWSON—When going up a hill it is best behind and going down it is best before.

Mr DIXON—I suppose the cost includes the rollers, because, I think, that will be an expensive thing as chains are sore on cast-iron rollers.

Mr LAWSON—We have never required to change any yet.

The PRESIDENT—The figures are the actual cost without reference to interest on money and depreciation.

Mr LAWSON—Mr Hyslop mentions there is nothing for interest on money, but as far as I know everything else is included.

Mr DRINNAN—You are likely to have some one to look after the rollers and keep them clean: the wages of these will be included?

Mr LAWSON—We have one man, and his wages are included. He goes over the whole.

The PRESIDENT—Might I suggest that at next meeting, in discussing this paper, members try to give us the cost per ton per mile, as is done in this paper, and also, where there is a very nice bit of horse road, the cost per ton per mile. I have got somewhere figures which shew that a horse has done in some of the pits of the district 60 tons a mile a day. Though no one likes better to see machinery employed than I do, I think we have very seldom given sufficient attention to roads upon which horses work. Where machinery is employed the roads must be good.

The discussion was then adjourned.

DISCUSSION OF MR R. T. MOORE'S PAPER.

The SECRETARY read the following communication from Mr JAMES H. RONALDSON:—

Without wandering from the consideration of the points taken up in Mr R. T. Moore's resumé of the recent French report on "Inspection in Fiery Mines in Belgium" to that of others foreign to the paper, one may well find it difficult to add to it any matter worthy of note, and still more difficult to point to anything in it erroneous or even misleading, for though the notice is necessary of a cursory nature, the most salient features in Belgian fiery mines have been touched on and exposed with accuracy. I might, however, be allowed to add one or two remarks. At page 256, the style of working at Hasard is described. If a comparison be made between this style and that of a seam at Tragegnies No. 5 Pit of the Mariemont and Bascoup

Collieries several differences are observable. The seam is 4′ 9″ thick, including 8″ of rubbish in the middle, is inclined at an angle of 30°, is non-fiery and is worked with naked lights. The districts extend in the direction of the strike 163 yards to each side of the inclined planes, from which the galleries driven parallel to the level and forming the pillars, start. The pillars have a width following the dip and rise of 22 yards if the roof be bad, and as much as 63 yards if the roof be good; these demensions being determined with a view to the facility of the future taking out of the pillars as influenced by the state of the roof. A narrow opening for ventilation is cut through the pillars about every 50 yards. In taking out the pillars, the lowest is first attacked at the further end, and is worked off in slices of 7 or 8 yards in the direction of the rise, much in the same way as the square pillars in the Clifton Hall Colliery, near Manchester, as recently described in the Transactions. Each of these stooping roads is fitted up with a roughly fixed inclined plane. All the wood is left in the gob which is well stowed. Sheet iron-pipes and air-crossings effect the ventilation in the roads being driven in the solid. During the taking out of the pillars the air current sweeps the face as in longwall working. It might be well to say that though prop-wood is occasionally drawn in Belgian seams, this is of rare occurrence in thin seams or thick ones. In the thin seams the wood used is slight, and the advantage gained by drawing it is not considered commensurate with the difficulty even where the danger does not absolutely preclude it, and in the thick seams, as at Gosson Lagasse, near Liége, where a 6 feet seem is worked longwall, the state of the roof does not generally admit of the wood being drawn. The idea on this point seems to be, that when a roof requires propping it is best to leave the wood alone. The long-wall differs slightly from the ordinary English style in that the face, whether going to the rise or the level, almost invariably presents a broken line, there being a step from two to six yards between each stall. The reason assigned for this arrangement is the better to keep up the roof at the face, though simplicity of ventilation be thereby somewhat lessened. When the direction of the stall roads is parallel to the level, these are placed at the lower end of the stall. In many pits, especially in

the Centre and the Borinage, in place of having one long inclined plane capable of serving several roads, it is preferred to have several small ones; the explanation given for this seemingly expensive style being sometimes the difficulty arising from the variation of inclination, at other times that it lessens the danger to the workmen from runaway hutches. However, if it be admitted that the safety of the pit may be affected by the unventilated *cul-de-sac* already existing between the inclined planes and the face, this arrangement is an aggravation of the evil. In the table, page 265, are the figures in column six in cubic feet, and if so, how are the numbers in seven, eight, and nine arrived at? That in some fiery seams an admixture of firedamp in considerable quantity with the air-current at the working face is at present looked on as an inevitable fact, I had the opportunity of seeing lately in one of the deepest pits of the Charleroi district, where the men at one part were working unconcernedly with a cap of 1⅜ inches on the lamps, or about 5% of firedamp, and the overman looked on it as an ordinary matter. There were eight walls in the section and the seam was very dry and dusty. The remark made regarding the whitening of the lower part of the chimney in the Museler lamp is well worth the prominence given to it. Though close to the flame, the whiteness does not become quickly sullied. With regard to the use of powder for blasting rock there is one notable exception to its use in the pits of the Marihaye company. Ever since a disastrous explosion in one of these pits in 1877, the directorate has prohibited the use of powder in the pits, and all stonework, be it in driving of stone headings, in sinking of pits, or, if other than hand labour be necessary, in the brushing of roads, is done by means of MM. Dubois & Francois' "Bosseyeuse"—a modification of their rock drill of a powerful stamp. The work is made as follows, shortly :—The holes having been bored by the machine as if for blasting but about 4″ in diameter, two long steel feathers and a plug are inserted in the holes, the boring-bit is replaced by a heavy ram and the plug is driven home by repeated blows from the rock-drill. This operation bursts off large pieces of rock. In stone headings, the cost by this system, without counting the up-keep of the air-compressors and rock-drills, is the same as if done by hand-boring and

powder, and 16% more than if by the rock-drill and powder. About three weeks ago, the deepening of one of the same company's pits was begun on this system. At the same pit, in a stone heading of 1000 yards, one of Körting's blowers is at work, and, together with the exhaust air from the rock-drill, airs the face where three men work. It is a small apparatus into which a jet of compressed air enters by a small pipe led off the main compressed air pipe, and by its action sucks in air from the gallery. It is fixed at the commencement of a line of 10 inch pipes, through which it sends the air to the face. In an absolute sense, it is far from being economical in its working, but it is small, simple, and easily fixed.

The PRESIDENT—These very valuable remarks shew the use of an institution such as this, and also the value of members at a distance. The fact of a paper, which was read here, having been seen by one of our young friends in Belgium, has led him to add a very interesting contribution. The remarks as to the substitution of machinery for gunpowder are especially worth notice.

Mr DIXON—I may say, in the first place, I am very much pleased with this paper, and I hope Mr Moore will translate the other two reports. There is one for Germany and another on the mines of this country. It is a very good thing to know what foreigners say about ourselves. In the first place, as regards this paper, it is quite evident that the laws with reference to mines' inspection in Belgium are rather strict; but I would like just to ask—do those restrictions result in fewer accidents in that country compared with similar mines in this country in similar circumstances? I think it is perhaps better that there should be a general good law and that exceptional mines should be made an exception to it than that there should be a strict law and nearly every mine should have exceptional regulations. I think most coalmasters may be credited with the wish to have no accidents in their mines, and if any coalmaster in this country had a mine such as that mentioned in the report with an inch and five-eighths of blue flame on the lamps, he would only be too glad that any mine inspector would give counsel and point out the best plan on which it could be worked. I do not see that in that way we could copy these very strict regulations

with advantage. There is one thing in the paper I am rather surprised at: there are two instances of bursts of gas when there were preventative bore-holes in advance. These seem to have been of no value, which is against the generally accepted idea on that subject. It is strange that bore-holes a considerable distance in advance of the face did not relieve the pressure which immediately afterwards burst the coal in a narrow place. The quantities of air passing along per man are very small compared with the best practice in this country; 85 and 100 cubic feet per minute per man is a very small quantity. In regard to ascensional ventilation, p. 260, it says—"In ascending ventilation (reads). But in describing the fittings of these collieries in the first place, it is said as a rule the pits are within 30 or 40 yards of one another, so if the ventilation goes away to the rise, it is bound to return to the dip again before it can get to the upcast shaft.

The PRESIDENT—No.

Mr DIXON—If that is the case, it comes to this: it is only in exceptional circumstances that system can be applied.

Mr R. T. MOORE.—The principle of ascensional ventilation is rather different as applied to Belgian mines than what it would be if applied to our flat seams. The seams in Belgium are very highly inclined, and they are worked in stages a fixed number of yards in depth, beginning at the top of the seam and going downwards. The air is made ascensional in each of these stages, going in at the lowest point and coming out at the highest.

Mr DIXON—There are flat seams as well; how do they do in cases of that kind?

Mr R. T. MOORE—There are very few flat seams in Belgium, and I presume if the ventilation cannot be made ascensional, the owners will apply for an exemption to the regulation. As Mr Dixon says the quantity of air per man is smaller than what would be considered good English practice, but this perhaps may be owing to the larger number of men required to raise a given quantity of coal in Belgium than in England. For if the quantity of air per hundred tons of coal raised be taken it will be found to compare favourably with that in English mines. Mining inspection in Belgium seems from the report to be much more minute than in England, but it is doubtful whether it is any more efficient,

because although there is in Belgium a greater number of inspectors, the workmen in England have the power of inspecting the mine themselves and calling the attention of the officials of the mine to any defect which may exist. If they are not satisfied with the steps taken to remedy the defect, they can and probably frequently do set the machinery of the law in motion by an anonymous letter to the inspector. By this power given to the workmen, then a much larger staff of inspectors is created than even the Belgian one and the mines may be more frequently examined.

Mr ROBSON proposed a hearty vote of thanks to the author of the paper for his great kindness and trouble in translating it for the benefit of the Institute.

The vote having been cordially given,

Mr R. T. MOORE thanked the members for their kindness in receiving his paper and the hearty vote of thanks they had given him.

The PRESIDENT had no doubt whatever that the observations of those French Engineers who had gone through the different countries would do much good, and he hoped that the suggestion of Mr Dixon would be carried out.

DISCUSSION OF MR DRINNAN'S PAPER.

The PRESIDENT—Mr Drinnan having the authority of the council I do not think that any remarks are called for from me on the matter. You have the paper before you, and, like all Mr Drinnan's work, it is ably put together.

Mr RONALDSON—It may be pointed out to Mr Drinnan that the examination required by General Rule 3 of the Coal Mines Act is simply an examination so far as ventilation is concerned, and that he assumes that it has a much wider application. Upon this wrong assumption for a basis he proceeds to build up his argument which must therefore fall to the ground.

Mr DRINNAN—I may as well say at once with regard to that, I would like to know from Mr Ronaldson whether men are allowed to go to their work without the roadways being examined otherwise than for ventilation.

Mr RONALDSON—General Rule No. 3 gives all the information on the point.

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Mr DRINNAN—I am not altogether sure what is being driven at, but as I understand it, you mean to convey the impression that the manager is responsible for having that done. In answer to that, I would say it is also the duty of the inspector to know if it is done.

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Mr DRINNAN—In answer to that, it may perhaps be as well to say this that the one object I had in view when I addressed myself to the paper was to try and make out what we really were responsible for. I thought in no other way could we arrive at what was required by the Act than by striving to ascertain what inspectors insisted on being done because the Act empowers them to see that the Act is carried into force. They above all persons ought to know if it is being enforced because the Act empowers them to see that the Act is carried into force. The main matter to which I made reference was this system, and not only in Scotland but in England, I found it universally to be the case that firemen and deputies have a large area of ground to go over; it is a considerable time since the Act came into operation, and plenty of opportunity has been given to inspectors if they had thought it was not in accordance with the Act, to have called it in question. Now, I maintain, from the fact it has not been so called in question they must be held to approve of it, and I maintain, also, they above all persons should know the Act, and that, therefore, in case of accidents we would be entitled to fall back on the Inspectors and say—"They approved of the system of inspection, and, therefore, we ought to be freed from blame for we were carrying out the Act according to their approval and determination." There are matters which an inspector brings before the manager, and if he fails to attend to them he will then bring them before the Home Secretary. I do think we have a

right in fairness to insist that this system of inspecting the roadways is approved by the inspectors all over the kingdom—not merely in Scotland; for I have known in England far larger areas gone over than here, but, no doubt, with the approval of the inspectors.

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Mr DRINNAN—I think Mr Hastie has brought forward arguments of his own in order that he may have the pleasure of confuting them, because I am not aware of having made any such statement as he has urged with regard to jurymen and referring men to the Act. I was referring to no particular kind of dangerous work to be done, and I would ask him to point out where in the Mines Act or any other Act you are to give particular instructions to the men that are to do that work. He will not find it there, nor in any other Act. They can employ what they consider a fit man and tell him to do it to the best of his knowledge, and that was what I meant. With regard to jurymen, he says I alleged that jurymen were uneducated. I said no such thing; what I did say was that "brains did not necessarily form a part of the possessions which entitled a man to sit as a juryman," and I say so still. Mr Hastie's experience may have been different from mine. Certainly, I count him singular if he has not met men who have sat on juries who have no more capability than a street scavenger. I have met such men, and I daresay it must be the experience of every one. My idea was with regard to that point that jurymen were certainly not competent not merely to decide on what certain other men had seen, but what were really questions of law and that they were not competent to do it because it requires men of the best minds to do that; the more so, that most of these cases contain most important issues, and I think the best men the country has should be appointed to try them. I wish it to be particularly understood that I make no charge of want of education. They are selected at random, and even comparatively uneducated men I have seen sitting on juries.

Mr SMART—I think we are indebted to Mr Drinnan for bringing the subject before us, as the passing of the Liability Act has entailed a considerable responsibility on coalmasters; and I think

we cannot too often bring such responsibility before every one engaged about a colliery. For my own part, I was somewhat of Mr Drinnan's idea as to the Act. I did not feel so much alarm at its passing as was done in England, because, looking at the old common law, as interpreted by the Scotch judges previous to 1860, it was something similar. Employers were held responsible for managers, and they are so still according to this Employers' Liability Act. But circumstances have altered a little since then. We have had the Mines Regulation Act passed in 1872, and by it we are compelled to employ competent persons to do certain duties. These duties are defined by the special rules which you may say is part and parcel of the Act. Well, in the first place, we have an engineman, pitheadman, bottomer, fireman, and roadman, even down to the little trapper boy. Now it seems to me the question is, where is the responsibility of the coalmaster to end? Is he liable for neglect of the little trapper boy? Is he liable for all those persons who are not called "managers?" One of the interpretations of the Act is that a person under superintendence is to be a man that does not work. Now, in all our collieries all those people do work. The Act has entitled us to employ competent men,—they are not said to have men having a charge. I would like very well to hear some other ideas on the matter as to where the responsibility is to end.

Mr JAMES ANDERSON, Rutherglen—I think the subject was a very proper one to bring before the Institute, but I think in doing so Mr Drinnan has rather mixed up things, because we have a Mines Regulation Act as well as the Employers' Liability Act, and the latter has reference to all classes of employers, as well as colliery owners. I think Mr Drinnan has mixed up the two, because an offence under the Mines Act is dealt with under that Act, and an offence under the other will be tried under the Liability Act. I think Mr Smart has touched on what I have myself a very strong feeling with regard to, viz., that under the one Act they are tied down to certain specific duties, and are to have certain specified persons for those duties, while the other brings us under pecuniary liability if these fail in their duty. I always thought the Act would be harmless but for that. The unfortunate thing as regards our discussion is that whatever opinion

we may have has no effect at all in point of law, because every case will be tried on its own merits, and it is not what we think but what the lawyers think. I am only speaking as far as my own personal opinion is concerned. As to the tribunal by which cases under the Act should be decided, my experience is that juries are much more liable to be led away by feeling than trained lawyers, and wherever a question of law emerges it should be dealt with by the judges and not by a jury.

Mr DRINNAN—I thought there was something Mr Hastie said that I had not taken up. This gentleman (Mr Anderson) has repeated it, viz., my taking up that part of the Act only which concerns mining. It was just simply because this Institute concerns itself with that only that I confined myself to that part. I had no other reason. Then the gentleman who has just sat down says it will not be our opinions but the opinions of the lawyers that will be taken. I concur with him that it will be so to a very large extent, but at the same time it is to be observed that the Act says these general rules are to be observed so far as "reasonably practicable." Who is to define that? The lawyers must rely on some other person than themselves, for they have no practical experience. Who then could they turn to? They would turn to the inspectors and ask them if they believed the examination would be a "reasonably practicable" one. That was why I wished to call attention to it. For to define that, I do not see any other person. They being from their position perfectly independent they are the only persons who can say whether the examination is a "reasonably practicable" one or not. A gentleman has said that even if stupidity were proved it is not a thing for which employers are responsible. I think I explain that further on (reads). I meant to say that a man might have a certificate as a mine manager and yet in regard to the point referred to be exceedingly stupid indeed.

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Mr DRINNAN—Gentlemen may perhaps think I am obtruding myself too often, but I am exceedingly anxious it should be perfectly understood what I mean. The President will not suspect me as being guilty of flattery when I say that I am anxious I should not fall in his estimation, but all I would do in order to

maintain that is to endeavour to make myself thoroughly understood by him, and then I must take the consequences. In regard to what I said as to "reasonably practicable," it was not that an inspector should go to the coal owner and say it was "reasonably practicable." What I had in view was an accident happening and the matter brought before a court of law. I say, in that case, if an employer were to maintain that he had been keeping up a "reasonably practicable" examination,—the only one that could be cited to give evidence, would be one of the inspectors as being least likely to be chargeable with having a bias. That was what I meant. I did not suppose he would go to the coal owner, or be required by the coal owner to say whether it was "reasonably practicable," but simply if a case were brought, he was the only one that could define that.

Mr DIXON—I have professionally had to do with one or two accidents under this Act; as yet, in regard to many points, it has to be interpreted. I quite agree with Mr Drinnan that juries are incompetent to interpret points of law as to who is liable or not liable, or who is a workman under the Act and who a man entrusted with superintendence. I think these are points that should first be settled by judges; in regard to what is reasonably practicable—that is a question for witnesses, such as mining engineers and others. They get a dozen on one side and a dozen on the other side, and the judge is the man to decide from the evidence what is right and what wrong. I can say the inspector will never be asked. The judge takes the evidence as brought before him; he does not send for the inspector and consult him.

On the motion of the President, a vote of thanks was given to Mr Drinnan for his paper.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 9th MARCH., 1882,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

RALPH MOORE, Esq., President, in the Chair.

The Minutes of the last General and Council Meetings were read and approved of, and signed by the President.

The following gentlemen were balloted for and admitted as Ordinary Members :—

WILLIAM FERRIE, Esq., Monkland Iron Works, Airdrie.
ANDREW WINNING, Oversman, New Farme Colliery, Rutherglen.

The following were nominated for election at next meeting :—

DAVID DUNN, Coalmaster, Rhinds, Baillieston.
ROBERT M'LAREN, Manager, Braehead and Newlands Collieries, Baillieston.
HUGH GRAHAM, Manager, Allanton Colliery, Hamilton.
JAMES YOUNG, Quarter Iron Works, Hamilton.

A New Rule as an amendment over the present rule under Sec. 8 was proposed by Mr Barrowman and seconded by Mr Ronaldson to the following effect :—

"That all papers shall be submitted to the Council fourteen days before the date when it is proposed that they be read, and the Council shall have power to decline any papers."

As required by the rules, the proposed amendment was delayed for discussion at next meeting.

Mr DRINNAN called attention to the isolated remarks which sometimes appeared in the reports on discussions of papers read before the Institute. This was apparently due to Members making remarks during the discussion and afterwards withdrawing them without communicating their intention to other Members who had made remarks based upon theirs.

The PRESIDENT hoped that the Council and Members would bear it in mind in future.

DETAILS OF LONGWALL WORKINGS.

By Mr JOHN HOGG, Motherwell.

Longwall work implies the extraction of all the coal in one operation, leaving no pillars to support the roof except those round the shaft, and in some cases along the sides of main roads.

It is the details of the operations applicable to the seams commonly wrought in the district by long-wall to which I will confine this paper, and will take first the

DIRECTION OF ROADWAYS.

The direction of the main roads is determined by the inclination of the seam, or special and local considerations; but the direction of the common roads is determined mostly by the bearing of the plain backs in the seam of coal or other mineral, by the nature of the coal, and also by the nature of the roof. The levels being driven at right angles to the dip and rise, if the nature of the coal will admit, the common places will follow in the same direction. To effect this, a heading is driven at right angles to the level, and the places are branched off it. Should there be a considerable rise and dip on the field, the leading way may be driven with a slope to suit haulage.

As a rule, coal works easiest when wrought off the smooth plain backs. These backs occur at distances varying from 10″ to 3′ or 4′, and the weight at the face not only breaks the coal off by these backs, but assists the collier in holing. But, though in almost every case coal will be easiest got from the plain, it may not be got in the best possible condition. If the coal is of a strong nature and the backs occur regularly at distances of 1 foot six inches to three feet, the coal will be got round and with little dross. But when the coal is soft and the backs occurring every ten or twelve inches, the coal will be very easily got, but will be small and yield much dross. In such cases it will be found of advantage to work the places on end of the coal. The seam is thus in a better condition to resist the pressure of the roof; as it opposes its strongest face to the action of the weight, it will stand till it is holed deeper and the coal will be got rounder. Even when the coal is soft and friable, it may be wrought on the plain and got in good condition where there is a few inches of fire-clay or "daugh" underneath. This not only serves to hole in, but saves the coal to some extent from being crushed by the weight. Other seams which work best every way on the plain of the coal will have to be wrought on end because of the roof. The plain backs in the coal are generally continued through the roof stone, and when these backs are keen, the roof will occasionally slip down between them all along the face. The benefit in such a case, if working the coal on end, is, that the road is also brushed "on end" of these backs, and though the roof should break down at the face, the fall is not likely to be so extensive. Again, it may suit the working of the coal and the maintenance of the roof for the roads to be driven half end and half plain. The line of the faces takes the shape of the arc of a circle and are holed through on each other. The level and heading can be double shifted, and the angle at which the roads are driven prevents one place from getting far from the main road before the next is branched off. I now come to the

FORMATION OF ROADS.

The expense incurred in making and maintaining the roads through the waste is a very serious item in long-wall, and too

much care can hardly be given to the first brushing and building of them. It is of great importance to keep the roads perfectly straight; if the buildings along the road-side are not built in a straight line that part which projects furthest into the road generally gets crushed over, obstructing the road-way and leaving the sides of the brushing without support; and if the buildings are not straight the sides of the brushing are not likely to be so. Thus, masses of the roof-stone or "boutons" are also left projecting out of the straight course and are almost certain to get broken off, being a source of danger and expense. Also, the rails must be twisted to get round the projection, which is not favourable to the haulage of the coal or to keeping the tramway in order. The direction being given to the roads, the brushers and builders must understand that they must be kept straight under penalty of having to do the work over again. Otherwise, the temptation to brush and build the roads to suit breaks in the roof may be too great for them, as, by taking advantage of these breaks or cracks, powder and time dressing the sides may be saved.

The buildings or pack-walls should be well built and stowed —the sides requiring to be built quite plumb and of the largest stones. The practice of building up corners and leaving the rest of the roadside unfinished till a more convenient time should not be allowed. The side of the building left unfinished will permit the roof of that part to yield and by and by break down, or, if the roof is too strong for that, the corner gets more than its fair share of the pressure and is damaged accordingly. The roof gradually settling down reaches and hides the top of the unfinished building and no more is thought of it, but the corner has been damaged and finally gives way, and the wonder with everyone is how such a good corner as that happened to fall into the road. I would insist on all the building being pinned tightly to the roof, so that the pressure may come down on every part alike. If buildings are allowed to pass unfinished in the way I have noticed, the sides of the brushing will naturally get slack, and the main roof more or less weakened. In other cases, though the building may be finished to the roof, all the care and attention is given to the corner alone and the rest very carelessly built

This also should be guarded against: for, though the corner is the most vulnerable part for the time being, it is so only until another building is built against it. It is then no longer a corner but merely part of a roadside, all of which, if possible, should be of uniform strength.

We do not always get a brushing bed yielding good building stones,—these being sometimes both small and of a soft nature. In this case, old wood may be used with great advantage if mixed in the buildings with the stones. In using the wood, it should be mixed uniformly along the roadside, and not at the corners only as is sometimes done. It does not do much good, but mostly harm, for the wood to be laid parallel with the roadside unless other pieces are passed into the building the opposite way both above and below, so as to tie it in. Broad thin wood 4 feet or 5 feet long is suitable for this purpose.

The height and width of roads will be subject to the nature of the roof beds, the height of the working, the quantity of refuse for building packs obtainable from the seam, and the distance they are likely to go before being cut off.

If the roof beds are strong and suitable for brushing and building, as much will be taken from them as fulfil the requirements as to height and material wanted for building. But it may and does sometimes occur that there is a limit to what can be brushed from the roof. Suppose a case where there is about three feet of good strong roof stone, and for some distance above this, soft unreliable material. It would be necessary to brush only say two feet, leaving the rest to form a roof. This may not give the height of road desired, and will cause slope or cutting-off roads to be driven at shorter intervals.

The height and width of roads being decided upon, it is important that the width of top of brushing should bear a proper relation to the width of building. To explain my meaning more fully, suppose the roads to be built 8ft. wide, and the thickness of brushing 3ft., I would suggest that the width at the top be no less than 5ft. This allows 1ft. 6in. on each for "cooming" or tunnelling the sides of brushing. In a moderately hard stone this will be found to be no more than what is required to dress the sides. If the thickness of brushing is only 2½ft., then with

the coal wrought cheaper on the whole. But the value of the system is shewn in the cases of thin seams of valuable coal which could not be worked nearly so cheaply if at all by stoop-and-room.

The cause of the coal being generally easily got is due to the weight of the overlying strata, which not only makes the holing easier, but brings down the coal without the use of powder, or even wedges. Another help to the getting of the coal is the fact that a number of places being almost in a straight line there are few rib sides to cut, and these only in the main roads.

To compare long-wall with stoop-and-room: in the former system we have the weight assisting to extract nearly every ton of coal; in the latter we have a proportion of the coal extracted by close work and no advantage obtained from the weight of strata above, and the other proportion (the stoops) having too much weight, so that the advantage of cheap rates for them is very often all lost by the large percentage of dross.

In working a number of long-wall places, I would prefer to have each place working so well forward to the one that gives it "cut" as that the miners can hole their places through on each other. To get the places holed deeply, "gibs" and "sprags" will have to be used. Where the roof is soft the places should be kept going regularly and speedily, built well up to the face, with short walls, and the distance between the roads kept uniform. If the distance between the roads is allowed to increase, the "cundies" get wider and the chances are that the roof will come in along the face. My objections to one place being driven before the others are, that in each place there is a rib side to cut which is one of the disadvantages of coal getting which long-wall is intended to prevent. There is the labour of cutting a shearing which must yield more or less dross; also, that the weight will not bear on two or three fathoms next the rib side of each place because it is held back on the point which is the cut side for the next place. This brings me to the next objection, which is, that the weight being too keen on this point the coal is crushed small and the roof will be troublesome to keep. If the roof breaks down, which it is likely to do here now and again, the ventilation is impeded until it is either redd through or the corner driven past the fall.

Long-wall is at its best when refuse enough to fill the waste is produced by the working. The weight will be kept better on the face and the roads will stand better; besides, less wood will be required for the roof. Still, thin seams with a good hard roof appear to work quite well even with no refuse from the working—the buildings on each side being formed entirely out of the brushing. The roof being firm does not break, but bends down behind the face until it reaches the pavement. Prop-wood to some extent will be required under any condition of roof, but as many of the props should be extracted as possible, and if practicable, other means used to support the roof. In thin seams, which do not "stow" themselves, pillars or "britishes" of stone are used, and when the miner gets accustomed to them he prefers them to trees, because they take a better hold on the roof. The material for these "britishes" is sometimes got out of the working itself, and in other cases from the brushing. Chocks or pillars of wood are also used occasionally. These are shifted forward as the face progresses. In the higher workings much of the wood used may be extracted. Though the most of it may be broken, it may be cut for thinner seams.

The PRESIDENT—We will be very glad to hear any remarks on this practical paper. It is a subject with which you are all familiar, and must have something to say anent it.

Mr DRINNAN—I entirely agree with the President as to the thoroughly practical nature of the paper, and believe also that it contains very useful suggestions, shewing undoubtedly that Mr Hogg has thoroughly thought out the matter. In order to give an impetus to the discussion, I wish to ask him how he does with wood that is built into the pack? He says it does not do to be laid parallel to the road unless you have other props running into the pack at right angles to the road. If he would answer now, or again, if it be more convenient, on what he rests the end of the prop that is in the pack,—whether in the loose dirt that may be in the centre, or has he a building on which he rests it?

Mr HOGG—The pieces that are passed into the building gener-

ally are only rested on the building itself—that is on the loose material that is flung into the inside to form the building. In some cases, a broad piece may be put inside, so that the weight coming down takes a greater hold of them. But I do not think that does much good. I think the weight is quite sufficient to keep the wood in.

Mr DRINNAN—I have seen frequently that when props were put into a building in the manner described, that is, with the end which was in the pack resting on soft material, whenever the weight had crushed the pack somewhat, the end of the prop which was in the centre was pressed down farther than the other end which rested on the facing building, and a displacement of the whole building was the result.

The PRESIDENT—I fancy that, unless the roof is very bad, if these pillars were perhaps 3 feet apart they would be as good as a continuous building,—that is, in a place where there is a difficulty in obtaining building material. There is a good deal, I think, in what Mr Hogg says about the powder, —the importance of having the powder so placed so as not to destroy the sides that are to be built up to, and also when the piece is taken out of the bottom, that you must not shatter the foundations, which I have seen done on many occasions, and hence the difficulty of keeping buildings where the roads are taken out at the bottom. I believe this is very much due to the shots being placed improperly, and so destroying the foundation. There is a good deal also, I think, in the buildings being kept tight and being kept well forward. As to his diagrams on the blackboard, in practice if you leave corners like that, even though you are going on plane, it is evident a crush must come on this (shewing) and make small coals. I am not quite clear as to the difference between long-wall and stoop-and-room with regard to the proportion of small. I think that depends a good deal on many circumstances. I can conceive it quite possible to work stoop-and-room and have as little small as with long-wall, provided in your first working you take out a small proportion of the coal. I rather incline to demur to the proposition that you make a greater proportion of round coal by long-wall than stoop-and-room properly gone about. The next point to which I should like Mr

Hogg's attention directed is the branch roads. He was saying if he had a bad roof he would have lower roads. My thinking is, whether a roof be good or bad, or in whatever state, the roads should be a certain size. In fact, I look on the road-making as the foundation of good mining. Depend upon it the height of the road has far more effect in producing coal cheaply than many are aware of. Talking of powder puts me in mind of a paper I got from one of my colleagues which I will read. It is the application of caustic lime to blasting. You are aware that when water is applied to lime it doubles its size. It is a very old idea. I believe many stone drifts were driven by means of lime as an explosive long before powder was applied to it. These gentlemen, at a colliery near to Derby, have improved on the idea, and they use caustic lime,—just lime shells ground down and put under pressure into cartridges. They then put it into the hole and place it in this way—I will read their description. It is a long-wall working, and my colleague, Mr Evans, has seen the thing done, and was very much pleased with the results (reads). "The mode of operating is to employ lime in a specially caustic state made from Mountain Limestone. This is ground to a fine powder and consolidated by a pressure of about 30 tons into the form of cartridges 2½ inches in diameter, having a groove along the side. The cartridges are then enclosed in waterproof paper and packed into air-tight boxes to protect them from damp, and are ready to be conveyed to the mine for use. Holes are first drilled close to the roof by means of a light boring machine, an iron tube about half-inch in diameter having a small external channel or groove on the upper side and a cap of calico on the end, and also fitted with a tap at the other end, is first inserted along the whole length of the bore-hole. The cartridges are then introduced and they are lightly rammed so as to ensure their filling the bore-hole. After the cartridges have been enclosed by tamping in the same way as with gunpowder a small force pump is connected with the tap at the end of the tube by means of a short flexible pipe and a quantity of water equal in bulk to the quantity of lime used, is forced in. The water being first driven to the far end of the shot-hole along the tube there, escapes through the calico cap into the lime and flows towards the front along the groove, saturating

the whole of the charge and driving out the air before it. The pipe connecting the pump with the tap is then detached and the tap is closed so as to prevent the escape of the steam generated by the action of the water on the lime and the flexible pipe is disconnected. Long experience has shown that after putting in the water there is always an interval of two minutes before the steam attains a high pressure, so that there is no danger in its use." It is a very simple operation; whether it is likely to solve the powder question on not, it is difficult to say; still it will be very odd if an old practice like this—what has been lying at our doors for hundreds of years—is to supply what we have been so long seeking to obtain. I could fancy the slowness of it is in its favour. Those who have tried dynamite know the action is so sudden it tears the mineral out; and in artillery if they used very fine powder they would burst their guns, but they use pebble powder, which is about the size of my finger, and that burns slowly, gives a little time, so to speak, till the force accumulates and discharges the gun with more effect. Hence the action of this lime, being gradual, turns out very much larger coal.

Mr DRINNAN—There is a very useful suggestion made by Mr Hogg in his paper, but I am not altogether sure how far he carries it out, and I think it well to call his attention again to the matter viz., the question of propping at the face before the shots are fired. I am not sure that Mr Hogg said how he would advise the props to be put in; but certainly I remember he advised its being done before shots were fired. I have always seen it most effectually done by those props being put in before the buildings were put up, and that allowed the weight to come down on the buildings more gradually, and, was therefore far less likely to destroy the buildings. That may be his idea, but I am not sure that it is especially stated in his paper.

Mr HOGG—In answer to the last remark, I think it is a good thing if the colliers could put up the trees along the roadsides in their proper place. Sometimes they do that, so that the weight coming down on these tend to break the roof at the proper place; but very often they get broken before the brushers come on, and if they are I would insist on the brushers putting up props as tightly as they can in line that the roof may be broken off them.

I think it very seldom would stand, but it may do good in breaking the roof. My practice would be to have them put up in a straight line and as tightly as possible. I would have them out when the buildings are put in if they could be taken out. In regard to this sketch on the black board, the reason I drew attention to that was that in a good many sketches of long-wall working in the "Transactions," the branches are shewn to be driven at right angles to the levels. Another thing is you can hardly get out of the difficulty if you drive a level in this direction and branch the place at right angles. By the time the level is driven the distance for another branch, the last must be a certain distance away from it. It is only in a case where the output is wanted immediately I would suggest this.

Mr DRINNAN—I rather think that practically the President's idea is the best one in regard to working the coal. Mr Hogg perhaps is forgetting that levels do not generally run perfectly level. Purposely they are driven a little to the rise for convenience in haulage. Therefore, though the first stall commenced working as soon as it was cut, it would be no more than sufficiently advanced to permit of the second one being started, when the level had advanced sufficiently to permit of it. Indeed, I have generally seen you had a difficulty in getting the second started away, the first stall being scarcely far enough forward.

Mr HOGG—If that is the case, it is a fact these sketches have appeared with corners on them like that.

The PRESIDENT—With regard to props, I think, I have seen frequently brushers putting up props in line, and as you say they must be in line to be effective for the purpose of breaking the roof.

Mr MACCREATH—I think Mr Hogg says after the brushing is past he prefers to take all the props out. I should like to know if he has had any experience in the use of sharpened trees on a road where it was necessary to have trees after the brushing?

Mr HOGG—Yes, if necessary to be placed in the roads for the sake of supporting the roof, I would sharpen the points and let them break off at the bottom. Besides that I would sharpen them occasionally—that is, weaken them at the foot so that they may sink into the pavement or get broken off. The plan is to go on weakening them until the roof settles.

The PRESIDENT—It is a common thing in some places to sharpen all the props they put up so that they may sink into the pavement.

The further discussion of the paper was adjourned.

MR HYSLOP'S PAPER.

The PRESIDENT said that unfortunately Mr Hyslop was unable to be present. He was sorry for this, but it would not prevent the discussion from proceeding, as afterwards Mr Hyslop would have an opportunity for replying.

Mr DIXON—Mr Hyslop is evidently very much in favour of chain haulage as compared with rope haulage. The chief disadvantage in adopting chain haulage, at any rate if you have the chain on the top of the hutch, is that the hutches cannot be heaped to the same extent as with the other system. I think a great point in cheapness of haulage, both above and under ground —but chiefly in the latter, as the winding power is a limited quantity—is to have as much on each hutch as possible. A hutch will weigh from 3 to 5 cwts. empty, and the more that can be got on to it the better, because you have always the empty hutch to haul, and the greater proportion you have between useful and dead weight the better. In that way, I would prefer some mode of haulage by which the hutches can be heaped. Since last meeting, I have gone into the subject of the cost of ropes as regards the haulage at Bent, and I find it about a halfpenny per ton.

The PRESIDENT—How much per mile?

Mr DIXON—I cannot say, because it is not very easy in our system to fix how far the coal is carried in each case. At any rate, I consider, when comparing rope haulage with chain haulage, the best system is that by which you can get the largest live weight for dead weight, and for this reason I think ropes are preferable. I like the system of chain haulage in many ways very much—it has the advantage that the chain wears a very long time, and large quantities may be hauled on the surface, where, I

think its advantages are greatest. One thing in haulage I have not seen mentioned anywhere, viz., where the power of gravity can be utilised without engine power. I was at a colliery in England where they had two seams 20 fathoms apart, and a mine with a gradient of one in six connecting them; the full hutches coming down that mine propelled both the full and the empty ones along level roads at the top and bottom of the mine for long distances. It was as nice a working arrangement as ever I saw, as it went without a hitch at about four miles an hour. It was worked by a chain, but a rope could be applied if desired.

Mr HASTIE—Before we put in the endless rope haulage at Greenfield, we had a road very nearly a mile in, and one point we considered very particularly was, that if we put in chain haulage we would not get headings on the hutches. Mr Hyslop remarks that no two collieries are alike, and a plan that will suit one colliery for haulage will not suit another. I am of the same opinion. I have gone over the cost for the last three years that we have used a wire rope, and I find it comes very near to Mr Dixon's figure. He makes it ½d per ton taking it roughly. I said in a former discussion that in four years the cost of rope per ton was ¾d. I have made it up for three years, and I find the cost of ropes is from ½d to ¾d per ton. In a former paper read here it was said at one colliery the labour for chain haulage cost a little over ½d per ton. I do not think endless rope haulage could be done for that. It costs us something more.

Mr HOGG—In reference to the price of ropes per ton on page 312, Mr Hyslop says (reads). If I look at it correctly, that only makes ·13 of 1d per ton. There is a difference between that and ½d per ton.

Mr HASTIE—I put it roughly at ¾d per ton for ropes, and 1d per ton for labour per mile.

Mr DRINNAN—Mr Dixon and Mr Hastie both lay considerable stress on the fact, which is not disputed, with chain haulage the attachment is generally in the centre of the hutch, and does not permit of the hutches being so well filled. I do not think that is so fatal an objection, as I have seen tubs loaded very considerably above the wood although the chain was in the middle. I have seen it in England, the attachment being like a fork fitted

on to the end of the hutch, and standing a foot or 18 inches above the wood, and the hutches were loaded on about a level with the attachment.

Mr ARCHIBALD H. CRICHTON—Touching on this same point—the heaping of hutches—I understand Mr Dixon at Bent attaches his hutches to rope by a side grip. Why cannot the same thing be as successful with a chain? I have had some experience of chain haulage where the hutches are attached at the side with a fork fixed on the centre start of the hutch without any objectionable experience cropping up.

The PRESIDENT—What is the dip and rise?

Mr CRICHTON—The load ascends an average gradient of 1 in 25 for about 400 yards, and then descends a gradient of 1 in 6 for about 80 yards. Regarding the tonnage conveyed per £1 of first cost of chain, Mr Hyslop, at p. 312, says (reads). Now, this same chain I am speaking of has already conveyed 86,000 tons of coal, independent of a considerable quantity of rubbish, and all the material required for underground work. The original cost of chain was £73, which calculated on the coal alone gives nearly 1180 tons per £1 of cost of chain, and I have no hesitation in saying it is good for twice as much more work yet.

Mr DIXON—A chain is very expensive as regards original cost and also very expensive as regards upkeep of hutches. I may say in the statement of cost of ropes at Bent made by me, there is nearly a half of it for the driving rope, which might be avoided by other arrangements. It cost ·21 pence per ton, and the drawing ropes only ·30. As regards our system, it costs almost nothing for labour.

Mr BISHOP—I have made up the cost of one of our underground endless haulage ropes at Cadzow, and I think you will find it compares very favourably indeed with the cost of endless chain haulage described in Mr Hyslop's paper. The rope is ¾ inch diameter, iron wire, and 1100 fathoms in length, and has been running for the last sixteen months. During that time it has drawn over 120,000 tons of coal an average distance of 1000 yards. One third of the distance has an average rise of 1 in 20 (steepest 1 in 9) against the full load. The remainder of the road falls 1 in 33 with full load. The hutches all run in trains of 12

= 7 tons 4 cwts. coal, attached to the rope by the ordinary form of shears mounted in a boggie and in charge of a Boggieman. The original cost of rope and upkeep during the time it has been running is £60. This gives a cost of ·12d per ton, or 2000 tons drawn per £1 of cost; or reduced to miles, ·21d per ton per mile, or 114,000 tons drawn one mile £100. The cost of haulage, including fuel and stores for engine, wire rope oil, cost of rope and wages of enginemen, boggiemen, and grease, = 1·75 per ton for distance drawn, or 3d per ton per mile. In comparing this rope with the Kinneil chain, account must be taken of the longer distance led by rope which helps to reduce the cost, but this is more than counter-balanced by the much larger quantity of mineral drawn by the chain. The principal item of cost is for boggiemen, which might be done without on a surface arrangement where all parts of the road are visible, but would not be safe below ground. I may mention the rope is still running, and likely to do so for three or four months yet, provided no accident takes place to it. The rope has travelled since it started a total distance of about 9000 miles.

Mr ARNOTT, in answer to the President, said—I am sorry I am not at present prepared to give any experience regarding Dykehead endless chain. The one I have working is at (Summerlee) Drumpellier, and is a $\frac{13}{16}$ inch chain, weighing 40 lbs. per fathom. The average gradient of the road is 1 in 5·3, the steepest part being 1 in 3½. The coals are drawn uphill, a distance of 385 fathoms, and the total length of chain is 800 fathoms. The hutches are put on the chain 70 feet apart, and there are 33 hutches altogether on full side, two-thirds of which are empty. The empty hutch weighs 4 cwt, and holds from 7 to 8 cwt. of coal. The attachment is on the top, and the load is level with the wood, except at each side where large pieces are put in for a heading, the hutches having been made wider for this purpose. The difficulty with us is, the chain in a short time gets into a crystalised state, owing to the jerking, caused by its rising and slipping in the driving drum. It has been running now only about a twelvemonth since we had it re-annealed, and when it breaks (which it has done twelve times during that period), or when a link is being cut, it flies in pieces like glass.

Mr CRICHTON—Will the vibration and slipping of the chain on the conical drum not tend to crystalise it quicker than if it was passing round a pulley on which the chain was not allowed to vibrate? The chain I have already spoken of is driven with a pitch pulley fitted with steel teeth, and the chain is quite free from the vibration and slipping that is common to the conical drum.

Mr R. T. MOORE—We have had to-night descriptions of various systems of underground haulage, and had their results considered from an economical point of view, but I think one point has been lost sight of in these calculations, that is, that in any of these systems, whether by chain or rope, the hutches are only drawn from points on the main road, and there always requires to be a separate system for lifting the hutches from the faces to the haulage. This entails extra cost for labour and loss of time in changing from the one system to the other, and, if this be taken into account in taking out the cost of haulage, I am not sure whether, as the President suggested at last meeting, horses are not the cheapest method of haulage. The following example of haulage by horses will give some data for comparison:—At Allanshaw Colliery, the coals are drawn from the faces along a road dipping with the load at an average gradient of 1 in 70. Four tubs, holding 4 tons of coal, are drawn at a time. During last week a horse lifted 729 tons of coal from the faces, and drew them a distance of $\frac{1}{3}$ of a mile. This gives $40\frac{1}{2}$ tons lifted from the face and drawn a mile in a day. Taking the cost of the horse at 16s a week, and the drawers' wages at 24s, this makes the cost of haulage less than 2d a ton per mile. I do not think any of the systems mentioned work much more economically than this.

Mr RONALDSON—Mr Hyslop at bottom of p. 309 says (reads). I would like to know how he keep the chains on the hutches while they are down in the bottom of the hollow, or is the weight of the chain in this case sufficient to keep it on the hutches?

Mr DRINNAN—I have seen the action described, and the weight of the chain holds it down.

The PRESIDENT, in drawing the discussion to a close for the night, said he was afraid none of them had gone thoroughly into the question whether chains or ropes were best. They had

only given their own ideas of what they found best for themselves, and he suggested before next night they might have still further discussion on the subject.

The discussion was then adjourned.

Before the close, the PRESIDENT read to the meeting the following table of statistics relating to the Eastern District of Scotland:—

COUNTIES.	OUTPUT OF COAL. TONS.	
	1881.	1880.
Clackmannan, Kinross, Perth, and Sutherland,	269,384	268,090
Edinburgh, ...	938,615	793,804
Fife, ...	2,023,810	1,930,511
Haddington, ...	246,341	243,302
Lanark (part of), ...	9,374,991	7,627,159
Linlithgow, ...	504,338	448,955
Stirling (part of), ...	791,401	707,622
	14,148,880	12,019,443
Fireclay, ...	177,969	173,249
Ironstone, ...	779,994	772,043
Shale (oil), ...	840,259	730,777
Total, ...	15,946,102	13,695,512
Persons employed, ...	42,721	41,276
Deaths by Accident, ...	75	68

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RULES,

AS REVISED AT A SPECIAL MEETING, 13TH APRIL, 1882.

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SECTION I.—OBJECTS.

I.—The objects of this Institute are to enable its Members to meet together at fixed times to discuss the means for the ventilation of Coal and other Mines, the Winning and Working of Collieries and Mines, the Prevention of Accidents, and the Advancement of the Sciences of Mining and Engineering.

SECTION II.—CONSTITUTION.

I.—The Institute to consist of Ordinary Members, Life Members, and Honorary Members.

II.—The Council of the Institute for the management of its affairs shall be chosen annually from the Members, and shall consist of a President, Four Vice-Presidents, Twelve Councillors, a Secretary, and a Treasurer.

SECTION III.—QUALIFICATION OF MEMBERS.

I.—Ordinary Members to be persons practising as Colliery Managers, Mining, Civil, or Mechanical Engineers, and other persons connected with, or interested in, Mining and Engineering, of whom the Council may approve.

II.—Life Members to be persons who shall compound for all future payments by a payment of Ten Guineas, or on such conditions as the Council may in writing accept.

III.—Honorary Members to be persons of whom, although not technically qualified, the Council may approve.

Section IV.—Election and Expulsion of Members.

I.—A recommendation for admission, according to Form A, in the appendix, to be forwarded to the Secretary, and by him to be laid before the next meeting of the Council. The recommendation to be signed by Two Ordinary Members or Life Members.

II.—The Election to take place at a General or Special Meeting by ballot; three-fifths of the votes tendered being necessary for election.

III.—In the case of non-election, no mention thereof shall be made in the minutes, nor any notice given to the unsuccessful candidate.

IV.—When the proposed candidate is elected, the Secretary shall give him notice thereof, according to Form B, but his name shall not be added to the list of Ordinary Members or Honorary Members until, and unless, within two months after notice of election as above, he shall have paid his first annual subscription, and signed the Form C, whereupon he shall be entitled to all privileges of Membership, including a copy of the Transactions issued in that year.

V.—The Transactions of the Institute shall not be forwarded to persons whose subscriptions are more than six months in arrear.

VI.—Any person whose subscription is twelve months in arrear shall be reported to the Council, who shall direct application to be made for it, according to Form D, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after suitable remonstrance by letter, in the form so provided (Form E), of erasing the name of the defaulter from the register of the Institute.

Section V.—Election of Officers.

I.—The election of Officers shall take place at the Annual General Meeting in the month of April in each year.

II.—The President, the Vice-Presidents, and Councillors to retire annually; but they shall be eligible for re-election with the exception of one Vice-President and the three Councillors who may have attended the fewest Council Meetings during the past year, and when such attendances are equal, the Council shall decide which of the Vice-Presidents and Councillors shall be re-nominated; but such persons shall be eligible for re-election after being one year out of office.

III.—Candidates to be put in nomination at the General Meeting preceding the Annual General Meeting, when the Council shall present a list of their retiring members who offer themselves for re-election. Any member to be entitled to add to the list of Candidates. In case of the decease or resignation of any Officer or Officers, notice thereof must be given at the next General or Special Meeting, and a new Officer or Officers elected at the succeeding General or Special Meeting, in accordance with the mode above-mentioned.

IV.—The Secretary and Treasurer shall be appointed every year by the Council, at the first meeting of the Council after the Annual General Meeting.

Section VI.—Meetings.

I.—There shall be Twelve Ordinary General Meetings in each year, to be held in Hamilton, unless elsewhere arranged for by the Council, on the second Thursday in every month. The Annual General Meeting to be held in the month of April.

II.—A Special Meeting of the Institute to be called whenever the Council make think fit, and also on a requisition to the Council distinctly specifying the reason thereof, signed by ten members.

III.—The Ordinary Members, Life Members, and Honorary Members to have notice of, and the privilege to attend all General and Special Meetings (but Ordinary Members and Life Members only to be entitled to vote on any question by ballot or otherwise.)

IV.—Every question, not otherwise provided for, which shall come before any Meeting of the Institute, shall be decided by the votes of the majority of the Members and Life Members then present. But the Council shall have the discretionary power of suspending the effect of such decision, if by them considered to be prejudicial to the interests of the Institute; and of referring the same to a Special or to the next General Meeting, and at least ten days before such meeting, the Secretary shall have sent, by printed circular, to every person enrolled in the Institute, explicit notice of the question in abeyance.

V.—Invitations shall be forwarded by the Council to any gentleman whose presence at the discussion they may think advisable; and strangers so invited shall be permitted to take part in the proceedings, but not to vote.

VI.—Any person enrolled in the Institute shall have power to introduce a friend or stranger (see Form F) to any of the General Meetings of the Institute, but such visitor shall not take part in the proceedings, except by permission of the meeting.

VII.—No alteration of the Rules to be made at any but the Annual General Meeting, or at a Special Meeting for that purpose; and the particulars of every such alteration shall be announced at a previous General Meeting and inserted in the minutes; and such Annual or Special Meeting shall have power to adopt any modification of such proposed alteration of, or addition to, the Rules.

Section VII.—Subscriptions.

I.—The Annual Subscription of each Ordinary Member shall be 10s 6d, excepting Coalmasters, Agents, Civil, Mining, and Mechanical Engineers, and other Members interested in but not actively engaged in Mining, whose subscription shall be £1 1s.

II.—All Annual Subscriptions to be payable in advance, and the same are to be considered due and payable at the April meeting of each year, or immediately after election.

Section VIII.—Communication by Members.

I.—All papers shall be submitted to the Council fourteen days be-

fore the date when it is proposed that they be read, and the Council shall have power to decline any papers. The Council shall direct whether any paper read before the Institute shall be printed in the Transactions; and notice shall be given to the writer within one week after it has been read, whether it is to be printed or not.

II.—The Council shall have the power to publish any or all of the communications as they may think proper.

III.—Three copies of each paper printed by the Institute shall be presented to the author for private use.

IV.—All proofs of discussion, forwarded to persons who have taken part therein for correction, must be returned to the Secretary within two days from the date of their receipt, otherwise they will be considered correct and be printed off.

V.—The Institute is not, as a body, responsible for the facts and opinions advanced in the papers which may be read, and in the discussions which may take place at the meetings of the Institute.

The copyright of all papers communicated to, and accepted for printing by the Council and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise without the written permission of the Council.

SECTION IX.—DUTIES OF THE OFFICERS AND COUNCIL.

I.—The President to be Chairman at all Meetings, and, in his absence, one of the Vice-Presidents. In the absence of a Vice-President, the Members present to elect a Chairman for that Meeting.

II.—The Funds of the Institute shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

III.—The Secretary shall be present at all the Meetings, and shall take minutes of the proceedings and read those of the preceding Meeting; but in the case of unavoidable absence, the Council to appoint some one to act for him.

IV.—All past Presidents shall be *ex officio* Members of the Council so long as they continue Members of the Institute; and Vice-Presidents, not re-elected, shall be *ex officio* Members of the Council for the following year.

V.—At Meetings of the Council five shall be a quorum, and the minutes of the Council's proceedings shall be at all times open to the inspection of the Members of the Institute. The President shall be *ex officio* chairman of every committee.

VI.—The Council shall have power to revise and correct proofs of communications and the discussions thereon, and to delete any portion or portions of the discussion which may be by them deemed unsuitable for publication.

VII.—At the Annual General Meeting the Council shall present a report of the proceedings, and an abstract of the accounts of the previous year, audited by two Ordinary Members who are not Members of the Council.

Section X.—Property of the Institute.

I.—All the Property of the Institute to be held by the Council in trust for the Institute.

II.—All Books, Drawings, Communications, &c., shall be accessible to all the Members of the Institute; and shall be held in trust by the Council, at the Rooms of the Institute in Hamilton, for the use of the Members.

III.—None of the property of the Institute, as Books, Drawings, &c., to be taken out of the Rooms of the Institute without the consent of the Council.

IV.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members or others, unless by written order from the Council.

V.—All donations to the Institute shall be enumerated in the Annual Report of the Council to the Members.

Section XI.—Disputes.

I.—Any difference of opinion arising regarding the interpretation of any of the foregoing Rules to be submitted to the Council, whose decision shall be final.

BYE-LAWS.

I.—The General Meetings to be conducted, as far as practicable, in the following order :—

1st.—The chair to be taken at Six p.m.

2d.—The minutes of the previous meeting to be read by the Secretary or person appointed; and, after being confirmed, to be signed by the Chairman of that meeting.

3rd.—The balloting of new nominations for membership shall be proceeded with and the result announced.

4th.—Communications by letter to be read by the Secretary, according to priority of date.

5th.—Communications from the Council to be read by the Secretary.

6th.—Discussion will be invited upon a paper or papers read at a previous meeting, copies of which, if printed, will have been circulated among the members.

7th.—The paper or papers announced for the meeting will be read.

8th.—With a view to the maintenance of order during discussions and to prevent them from degenerating into mere conversations, no remarks will be considered in order unless the speaker is standing.

II.—Any member changing his residence to give notice in writing to the Secretary.

APPENDIX.

[FORM A.]

Name in full, Mr
Designation or occupation,
Address,
being desirous of admission into the Mining Institute of Scotland, we, the undersigned, propose and recommend that he shall become a thereof.

Proposed by } } Signature of two Members.

Dated 18

See Rules.
Section III.—Qualification of Members.
Section IV.—Articles I. and II.—Election of Members.

[FORM B.]

SIR,—I beg to inform you, that on the day of you were elected a of the Mining Institute of Scotland; but, in conformity with its Rules, your election cannot be confirmed until the enclosed Form be returned to me with your signature, and until your first annual subscription, £ , be paid.

If not paid within two months from this date, the election will be void, under Rule IV., Section IV.

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

[FORM C.]

I, the undersigned, being elected an of the Mining Institute of Scotland, do hereby agree that I will be governed by the regulations of the said Institute as they are now formed, or as they may be hereafter altered; that I will advance the objects of the Institute as far as shall be in my power, and

will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can, provided that whenever I signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period), be free from this obligation.

Witness my hand this day of

Signature.

[FORM D.]

I am directed by the Council of the Mining Institute of Scotland to draw your attention to Rule VI., Section IV., and to remind you that the sum of £ of your annual subscription remains unpaid, and that you are, in consequence, in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay.

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

[FORM E.]

SIR,—I am directed by the Council of the Mining Institute of Scotland to inform you that in consequence of your arrears of subscription, and in pursuance of Rule VI., Section IV., the Council have declared by special vote, on the day of 18 , that you have forfeited your claim to belong to the Institute, and your name will be, in consequence, expunged from the Register, unless payment is made previous to 18

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

FORM F.]

Admit
of
to the Meeting on Thursday, the
Signature of Member
The chair to be taken at Six P.M.

I undertake to abide by the regulations of the Mining Institute of Scotland, and not to aid in any unauthorised publication of the proceedings.

Signature of Visitor,

Not transferable.

The Mining Institute of Scotland.

1881-82.

HONORARY MEMBERS.

1. Alexander, William, H.M. Inspector of Mines, 23 India Street, Glasgow.
2. Moore, Ralph, H.M. Inspector of Mines, Croft Villa, Rutherglen *(President)*.

ORDINARY MEMBERS.

3. Adams, James, Hill of Beath, Fife.
4. Aitken, Henry, Darrock, Falkirk *(Member of Council)*.
5. Allan, James, Garturk Colliery, Coatbridge.
6. Allan, Robert, Gartnavel, Maryhill.
7. Allan, William, Woodyets and Dennymills Mines, Denny.
8. Allardice, James, Eastfield Colliery, Cambuslang.
9. Anderson, David, Clydesdale Street, Hamilton *(Member of Council)*.
10. Anderson, David, Little Raith Colliery, Cowdenbeath.
11. Anderson, George, Barkip Colliery, Dalry.
12. Anderson, George, Crosshill Colliery, Slamannan.
13. Anderson, James, Farme Colliery, Rutherglen.
14. Anderson, John, Shottstown, Pennicuik.
15. Anderson, Thomas, Kirkwood Colliery, Coatbridge.

16. Andrew, Robert, Lassodie Colliery, Dunfermline.
17. Andrew, William, Lassodie Colliery, Dunfermline.
18. Archibald, William, Clippens Colliery, Johnstone.
19. Arnott, Thomas, Summerlee Iron Works, Coatbridge.
20. Arrol, T., Clutha Iron Works, Glasgow.
21. Austine, John, Oak Lodge, Hamilton *(Member of Council).*

22. Baird, Archibald, Park Road, Hamilton.
23. Baird, Matthew, 67 Robertson Street, Glasgow.
24. Baird, Robert, 139 St. Vincent Street, Glasgow.
25. Barclay, W. P., 1 Princes Street, Kilmarnock.
26. Barr, James, Longlee Colliery, Larkhall.
27. Barr, William, Over-Dalserf Colliery, Larkhall.
28. Barrowman, James, Ardenlea, Portland Park, Hamilton *(Member of Council).*
29. Barrowman, James, 16 Union Park, Bonnyrigg.
30. Baxter, Robert, East Benhar Colliery, Fauldhouse.
31. Beavridge, John, Kelty Colliery, Blairadam.
32. Begg, Gilbert Burns, Brandon Street, Motherwell *(Past President, Member of Council.*
33. Begg, John, Whitehill Colliery, Rosewell.
34. Beith, Robert, Clyde Coal Company, Hamilton.
35. Bell, James, San Fermin Mining Co., Portugalete, Bilbao.
36. Birrel, George, West of Fife Coal Company, Guildhall Street, Dunfermline.
37. Bishop, George A., Cadzow Colliery, Hamilton.
38. Blackadder, Alexander, Stand Colliery, Airdrie.
39. Blyth, Alexander, Bent Colliery, Hamilton *(Member of Council).*
40. *Borland, David, Udston Colliery, Hamilton.

*Deceased.

41. Borland, Thomas, Clyde Iron Works, Tollcross, Glasgow.
42. Bowie, Hunter, Lugar Iron Works, Old Cumnock.
43. Brand, A. Douglas, 6 Dixon Street, Glasgow.
44. Brown, George, Longriggend Colliery, Airdrie.
45. Brown, Thomas M., Lanemark Colliery, New Cumnock.
46. Bryden, David, Coylton, Ayr.
47. Buchanan, D. C. R. C., Drumpellier, Coatbridge.

48. Calderwood, Robert, Cradley, near Brierley Hill, Staffordshire.
49. Calderwood, Robert, Oakbank Shale Works, Mid-Calder.
50. Cameron, Robert, 123 St. Vincent Street, Glasgow.
51. Campbell, Thomas, Spindleside Colliery, Clelland.
52. Carlow, Charles, The Fife Coal Company, Leven.
53. Carmichael, Robert, High Blantyre Road, Burnbank.
54. Chambers, William, Dalziel Saw Mills, Motherwell.
55. Christison, Robert, Gray Street, Shotts.
56. Clark, James, Eddlewood Colliery, Hamilton.
57. Clarke, J. A., Ayr Colliery, Ayr.
58. Clelland, Alex., Cadder Ironstone Works, Bishopbriggs.
59. Clelland, James, Carronhall Colliery, Falkirk.
60. Cochrane, Neil, Auchinheath Colliery, Lesmahagow.
61. Cook, Robert, Halbeath, Fife.
62. Cowan, David, Carron Iron Works, Falkirk.
63. Cowie, George, Springwells Colliery, Airdrie.
64. Cowie, James, Messrs Baird & Co., Kilsyth.
65. Cranston, David, Muldron Pits, Fauldhouse.
66. Crichton, A. H., Gartness, Airdrie.
67. Crookston, Andrew, Wemyss Colliery, by Dysart, Fife.
68. Crookston, Thomas, Shields Colliery, Motherwell.
69. Crossley, William, 153 Queen Street, Glasgow.
70. Cuninghame, Alex., Gavin Bank, Hamilton.
71. Cunninghame, Archibald, Eglinton Iron Coy., Dalry.
72. Cuninghame, J. C., 127 St. Vincent Street, Glasgow.
73. Cuninghame, John, 127 St. Vincent Street, Glasgow.
74. Cuthbert, Robert, Gauchalland Colliery, Galston.

75. Dalzell, John B., Lesmahagow.
76. Danks, Henry, Green Colliery, Wishaw.
77. Darling, John, Cleugh Gas Coal Works, Forth, Lanark.
78. Dewar, Peter, Braidwood Colliery, Carluke.
79. Dewar, Robert, Harthill Colliery, Whitburn.
80. Dewar, Thomas, Glenclelland Colliery, Wishaw.
81. Dick, James, Knownoble, Wishaw.
82. Dixon, James S., Bent Colliery, Hamilton *(Vice-President)*.
83. Docherty, John, Cowdenhill, Bo'ness.

84. Drinnan, John, Arden Colliery, Airdrie.
85. Duncan, Frederick, 1 Dixon Street, Glasgow.
86. Duncan, John, Leven Colliery, Leven.
87. Dunn, John, Bothwell.
88. Durie, John, Elphinstone Colliery, Tranent.

89. Erskine, George, Lochgelly, Fife.

90. Falconer, Thomas, Fordell Colliery, Crossgates, Fife.
91. Faulds, Alexander, Burnside House, Old Cumnock.
92. Ferguson, David, Hematite Iron Works, Harrington, Cumberland.
93. Ferguson, Duncan, Lochore and Capeldrae Collieries, Lochgelly.
94. Forbes, Alexander.
95. Forgie, James T., Craigston Square, Lugar, Old Cumnock.
96. Fraser, William, Uphall Mineral Oil Co., Uphall.
97. French, John, Millcroft Cottage, Rutherglen Road, Glasgow.
98. Frew, Robert, Bath Street, Glasgow.
99. Frew, Wm., Raploch Colliery, Larkhall.
100. Fulton, David, Dalquharran, Maybole.

101. Galloway, John, Barleith and Dollar Collieries, Hurlford, Ayrshire *(Member of Council)*.
102. Galloway, T. Lindsay, 28 St. Enoch Square, Glasgow.
103. Gardiner, Archibald, Glentore Colliery, Airdrie.
104. Gardiner, David, Meiklehill Colliery, Kirkintilloch.
105. Gardiner, Thomas, jun., Auldton Collieries, Dalserf.
106. Gavin, James, Carfin Colliery, Motherwell.
107. Geddes, G. H., 142 Princes Street, Edinburgh.
108. Gemmell, James, Govan Colliery, Glasgow.
109. Gibb, Robert, Pollock Colliery, Pollockshaws.
110. Gilchrist, Archibald, Polton Collieries, Bonnyrigg, near Edinburgh.
111. Gilchrist, James, Earnock Colliery, Hamilton *(Secretary)*.
112. Gillon, William, Townlands Colliery, Hamilton.
113. Gilmour, Allan, Portland Colliery, Kilmarnock.
114. Gilmour, Daniel, Portland Colliery, Kilmarnock.

115. Gilmour, James, Duchray Colliery, Coylton, Ayr.
116. Gilmour, John.
117. Gilmour, Joseph, Goatfoot Colliery, Galston.
118. Glen, Robert, Eastfield Colliery, Cambuslang.
119. Gordon, Gavin C., Knightswood Colliery, Maryhill.
120. Grainger, W. N., Clydesdale Street, Hamilton.
121. Grant, John, Bothwell Collieries, Bothwell.
122. Grant, Robert, Limerigg Colliery, Slamannan.
123. Grant, T. M., Townholm Engine Works, Kilmarnock.
124. Gray, Archibald, Stanley Bank, Dalry.
125. Gray, James, Linridge Colliery, Newarthill.
126. Gray, William, Lugar Iron Works, Old Cumnock.
127. Greig, John, Coltness Iron Works, Newmains.
128. Grierson, Thomas, Glebe Colliery, Douglas.

129. Haddow, John, Armiston Colliery, Gorebridge.
130. Hamilton, John G. C., Dalziel, Motherwell.
131. Hamilton, Robert, Harbour Buildings, Ardrossan.
132. Hamilton, Thomas, 11 Coal Exchange, Glasgow.
133. Hardie, James, Benhar, Whitburn.
134. Hart, James, Gauchland Colliery, Galston.
135. Hart, John, Clyde Iron Works, Tollcross.
136. Hastie, James, Greenfield Colliery, Hamilton *(Member of Council).*
137. Hastie, William, Gilmilnscroft, Auchinleck.
138. Henderson, Andrew, Wellshot Colliery, Cambuslang.
139. Hendrie, John, Maryville Colliery, Uddingston.
140. Herd, Peter, Dunniker Colliery, Kirkcaldy.
141. Herd, Thomas, Stane Colliery, Shotts.
142. Hill, James, Burnbank, Hamilton.
143. Hodson, James, Liverpool Road, St. Helens, Lancashire.
144. Hogg, John, North Motherwell Colliery, Motherwell *(Member of Council).*
145. Hogg, William, Carnmoore Cottage, Forth, by Lanark.
146. Hood, Archibald, 6 Bute Crescent, Cardiff.
147. Hunter, A., Alloa Colliery, Alloa.
148. Hunter, Andrew, Orbiston Colliery, Bellshill.
149. *Hunter, John, Woodend Colliery, Bathgate.

*Deceased.

150. Hurll, Mark, Glenboig, Coatbridge.
151. Husband, John, Ibrox Colliery, Govan.
152. Hutchison, Joseph, Woodside Colliery, Dalserf.
153. Hyslop, Jonathan, Kinneil Iron Works, Bo'ness.

154. Ireland, Thomas, Largoward, Kilconquhar, Fife.
155. Irvine, C. M'Laren, Fence Colliery, Blackwood, Lesmahagow.

156. Jackson, Douglas, Ponfeigh, Douglas.
157. Jamieson, A., Fairview Cottage, Bellshill.
158. Jamieson, Andrew, College of Science and Art, Glasgow.
159. Jamieson, Crawford, Uphall Oil Co. (Limited), Crossgreen, Uphall.
160. Jamieson, Robert, Polkemmet Cottage, Bathgate.
161. Jamieson, Robert, Twecher Colliery, Kilsyth.
162. Jamieson, William, Addiewell Oil Works, West Calder.
163. Jeffrey, Andrew, Rankinston Colliery, Patna.
164. Johnstone, David, 12 York Street, Glasgow.
165. Johnstone, Henry Ronald, Haywood Gas Coal Co., Lanark.
166. Johnstone, Hugh, Garscadden Works, Bearsden.
167. Johnstone, Thomas, Bothwell Collieries, Bothwell.

168. Kerr, Archibald, Barncluith Colliery, Hamilton.
169. Kerr, Archibald, 21 John Street, Hamilton.
170. Kirkwood, Archibald, Dalzell Colliery, Motherwell.
171. Kirkwood, William, Larkhall.
172. Kirkwood, William, Inkerman Works, Paisley.
173. Knox, James, Allanton Colliery, Newmains.

174. Laird, Alexander, 156 Buccleuch Street, Glasgow.
175. Langlands, John, Carfin Colliery, Motherwell.
176. Law, Alex., 5 Millbrae Terrace, Langside.
177. Legat, A. S., Loanhead Colliery, Edinburgh.
178. Leggete, John, Birkenshaw, Larkhall.
179. Liddell, Robert, 71 Waterloo Street, Glasgow.
180. Livingstone, Archibald, Glencavil, Ballymena, Ireland.
181. Loudon, John, Westerhallhill Colliery, Baillieston.
182. Love, Henry, 55 Brandon Street, Motherwell.

183. Love, John, Haughhead Colliery, Hamilton *(Member of Council).*
184. Love, William, Shotts Iron Coy., Shotts.

185. Mackenzie, William, Newbattle Collieries, Dalkeith.
186. Makepeace, Hugh R., Bog and Home Farm Collieries, Larkhall.
187. Malcolm, James, Craigneuk Colliery, Motherwell.
188. Marshall, R. A., 170 Hope Street, Glasgow.
189. Martin, Robert, Limestone Quarries, Ballintoy, County Antrim, Ireland.
190. Martin, William, Douglas Park Colliery, Bellshill.
191. Mathie, James, Cornsilloch and Millburn Collieries, Larkhall.
192. Maxwell, James, Thrashbush Colliery, Airdrie.
193. Meiklejohn, John, Westfield Iron Works, Dalkeith.
194. Miller, Archibald, Wood Merchant, Motherwell.
196. Mitchell, George A., 67 West Nile Street, Glasgow.
196. Mitchell, James F., 175 Hope Street, Glasgow.
197. Moffat, Peter, 16 Ure Place, Montrose Street, Glasgow.
198. Moodie, Thomas, Devon Colliery, Alloa.
199. Moore, Joseph, Smeaton Park, Inveresk.
200. Moore, Ralph, Smeaton Park, Inveresk.
201. Moore, Robert T., Croft Villa, Rutherglen.
202. Morison, D. P., Collingwood Street, Newcastle-on-Tyne.
203. Morison, John, Newbattle Collieries, Dalkeith.
204. Morton, James, Langloan Iron Works, Coatbridge.
205. Morton, John, Auchenharvie Colliery, Saltcoats.
206. Morton, R. M., Clydeford House, Cambuslang.
207. Muir, Thomas, Wester Gartshore Colliery, Kirkintilloch.
208. Muir, W. W., Coltness Colliery, Newmains.
209. Mungall, Henry, Cowdenbeath Collieries, Cowdenbeath *(Member of Council).*
210. Munro, James, Quarter Iron Works, Hamilton.
211. Munroe, H. S., H. Grevel, 33 King Street, Covent Garden, London, W.C.
212. Murray, John, Greengairs, Airdrie.

213. M'Beth, Peter, Callander Coal Co., Falkirk.

214. M'Cairn, Nicol, Prestonlinks, Prestonpans.
215. M'Callum, Alexander, Benhar Coal Co. (Limited), Portobello.
216. M'Cosh, A. K., Gartsherrie Iron Works, Coatbridge.
217. M'Creath, G. W., 95 Bath Street, Glasgow.
218. M'Creath, James, 95 Bath Street, Glasgow (*Vice-President*).
219. M'Culloch, John, Solsgirth Colliery, Kirkintilloch.
220. M'Culloch, William, Linkieburn House, Muirkirk.
221. M'Donald, John, Greenhill Colliery, Holytown.
222. M'Donald, John, Haughhead Colliery, Hamilton.
223. M'Donald, Symington, Lochgelly Iron and Coal Co., Lochgelly.
224. M'Farlane, Malcolm, Glenduffhill Colliery, Shettleston.
225. M'Feddris, William, Cadzow Colliery, Hamilton.
226. M'Gee, John, Tillicoultry Colliery, Tillicoultry.
227. *M'Intosh, John, Blairhall Colliery, Culross.

*Deceased.

228. M'Kay, Andrew, Grangemouth Coal Co., Grangemouth.
229. M'Kay, James, Spittalhill Colliery, Newton.
230. M'Kenzie, Kenneth, New Bank Colliery, New Cumnock.
231. M'Killop, Archibald, Muiravonside Colliery, Linlithgow.
232. M'Latchy, Alexander L., Woodend Cottage, Hurlford, Kilmarnock.
233. M'Lean, Andrew, Hill Colliery, Lesmahagow.
234. M'Nab, John, Flemington Coal Co. (Ld.), Cambuslang.
235. M'Naughton, James, 11 West Regent Street, Glasgow.
236. M'Neil, James, Maryville Colliery, Uddingston.
237. M'Neil, Robert, Maryville Colliery, Uddingston.
238. M'Pherson, Gilbert, Tribbock Colliery, Coylton, Ayr.
239. M'Vicar, Hamilton, Monkland Iron and Coal Works, Airdrie.
240. Nasmyth, A., Donibristle Colliery, Crossgates, Fife.
241. Nasmyth, A. H., Donibristle Colliery, Crossgates, Fife.
242. Nasmyth, J. A., Donibristle Colliery, Crossgates, Fife.
243. Neilson, Benjamin, Niddrie Colliery, Portobello.
244. Neish, George.
245. Ness, Henry, Muircockhall Colliery, Dunfermline.
246. Nimmo, Thomas, Fauldhouse Colliery, Fauldhouse.
247. Ormiston, A. R., 95 Bath Street, Glasgow.
248. Ormiston, James, Castlehill Iron Works, Carluke.

249. Orr, Thomas, Morningside Colliery, Newmains.

250. Park, John, Stonelaw Colliery, Rutherglen.
251. Park, Joseph, Allanshaw Colliery, Hamilton.
252. Paterson, Hugh, Braidhurst Colliery, Motherwell.
253. Paterson, John, Oak Villa, Uddingston.
254. Paton, John.
255. Paul, James, Law Colliery, Carluke.
256. Paul, James, Wilsontown House, Wilsontown.
257. Penman, William M., Blairingone Colliery, Dollar.
258. Pettigrew, Robert, 66 Flowerhill Street, Airdrie.
259. Philips, John, Braidwood, Carluke.
260. Pitcairn, Gilbert, West Limerigg, Slamannan.
261. Pratt, George, 2 Elmbank Street, Glasgow.
262. Prentice, James, Brownyside Colliery, Airdrie.
263. Prentice, Joseph, Addiewell Colliery, West Calder.
264. Prentice, William, Dalmellington Iron Co., Ayrshire.
265. Prentice, Thomas, Addiewell Works, West Calder.
266. Pringle, James, Govan Colliery, Glasgow.

267. Ramsay, William, Messrs Wm. Baird & Co., Gartsherrie.
268. Rankin, David, 75 West Nile Street, Glasgow.
269. Rankine, John, jun., Dungray Colliery, Airdrie.
270. Reid, Alex. G., Quarter Iron Works, Hamilton.
271. Reid, John, Loanhead House, Baillieston.
272. Rigg, Alexander, Dykehead Colliery, Hurlford.
273. Ritchie, Alex., Cleland Colliery, Newarthill.
274. Robertson, Alex., Newton Colliery, Cambuslang.
275. Robertson, Archd., Bathville Colliery, Armadale.
276. Robertson, David, Dalquharran Colliery, Maybole.
277. Robertson, David, 36 Glassford Street, Glasgow.
278. Robertson, J., Haywood Colliery, Lanark.
279. Robertson, James, Braehead, Baillieston.
280. Robertson, Robert, Bowhouse, by Linlithgow.
281. Robertson, John, Lanemark Colliery, New Cumnock.
282. Robertson, William, 123 St. Vincent Street, Glasgow.
283. Robinson, Edwin, West Glentore Coal Coy. (Limited), Airdrie.

284. Robson, J. T., Cambuslang *(Vice-President).*
285. Rodger, J. L., 3 Osburn Road, Copeland Road, Govan.
286. Ronaldson, James H., 8 Rue de l' Universite, Liege.
287. Ronaldson, J. M., Belton Villa, Pollokshields *(Vice-President).*
288. Ross, Alexander, 165 Oakfield Place, Motherwell.
289. Ross, James, Drumpellier Colliery, Coatbridge.
290. Ross, Michael, Clyde Bridge, Hamilton *(Treasurer).*
291. Rowan, Henry, Avondale Cottage, Uddingston.
292. Roxburgh, Alexander, Alloa Coal Co., Alloa.
293. Roy, William, Limerig and West Drumclair Collieries, Slamannan.
294. Russell, James, Elgin and Wellwood Collieries, Dunfermline.
295. Russell, Robert, Coltness Iron Works, Newmains.
296. Russell, W. S., Elderslie and Annandale Collieries, Kilmarnock.

297. Schuman, Sig., 5 St. Vincent Place, Glasgow.
298. Scobie, William, Barr Colliery, Beith.
299. Scott, John, Calder Iron Works, Coatbridge.
300. Semple, William, Benquhat, Dalmellington.
301. Semple, William, sen., Goatfoot Colliery, Galston.
302. Sharp, A., Omoa and Cleland Iron and Coal Co., Motherwell.
303. Sharp, George, Duchray Colliery, Coylton, Ayr.
304. Simpson, Alex., Albert Road, Pollokshields.
305. Simpson, Dundas, Souterhouse Colliery, Coatbridge.
306. Simpson, James, North Linrigg Colliery, Holytown.
307. Sloss, James, Auchlochan, Lesmahagow.
308. Smith, Hamilton, Cadzow Colliery, Hamilton.
309. Smart, James, Angus Lodge, Hamilton *(Member of Council).*
310. Smith, James, Blantyre Colliery, High Blantyre.
311. Smith, James, Brandon Street, Motherwell.
312. Smith, John, Cannock Lodge Colliery, Bloxwick, Staffordshire.
313. Smith, John, Rosehall Colliery, Coatbridge.
314. Sommerville, William, Bredisholm Colliery, Uddingston.
315. Southern, Edmund O., 49 Duke Street, Whitehaven.
316. Speirs, Alex., jun., 28 St. Enoch Square, Glasgow.
317. Spowart, Thomas, Broomhead, Dunfermline.

318. Stevenson, Graham, Airdrie.
319. Stevenson, John, Lilliehill House, Dunfermline.
320. Stewart, Alex., Tharsis Mines, Huelva, Spain.
321. Stewart, H., Tranent Colliery, Tranent.
322. Stirling, John, Banknock Colliery, Denny.
323. Stirling, Walter, Rawyards, Airdrie.
324. Strain, Hugh, Nettlehole Colliery, Airdrie.
325. Sturrock, John G., Skerrington Colliery, Hurlford.

326. Taylor, Lachlan, Brass Foundry, Hamilton.
327. Telfer, Henry, Overtown Colliery, Wishaw *(Member of Council).*
328. Tennant, John, Auchingramont, Hamilton.
329. Terris, Henry, Clackmannan Colliery, Clackmannan.
330. Tennent, Robert, Springbank Colliery, Airdrie.
331. Thom, Archibald, Bothwell Park Colliery, Bothwell.
332. Thomas, Davey, Cowdenbeath, Fife.
333. Thomas, Shenton, Blantyre Collieries, High Blantyre.
334. Thomson, Abram, Larkhall.
335. Thomson, Alex., Springbank Colliery, Airdrie.
336. Thomson, A. M'D., Kirkgreen, Muirkirk.
337. Thomson, Charles, Calder Iron Works, Coatbridge.
338. Thomson, John, Stevenston Colliery, Holytown.
339. Thomson, Richard, Wilsontown Colliery, Lanark.
340. Thomson, Samuel, Jerviston House, Motherwell.
341. Thomson, Thomas, Balquhatson Colliery, Slamannan.
342. Thornton, Peter, Crofthead, Fauldhouse.
343. Thornton, Thomas, Crofthead, Fauldhouse.
344. Thornton, Thomas, jun., Auchinheath Colliery, Lesmahagow.
345. Topping, R. M., Blantyre Foundry, Blantyre.
346. Torrance, James W., 69 Buchanan Street, Glasgow.
347. Turner, William, Chapel Colliery, Newmains.
348. Twaddle, William, Ferniegair, Hamilton.

349. Ure, John Y., Udston Colliery, Hamilton.

350. Waddell, James, Mauldslie Colliery, Carluke.
351. Waddell, Robert, Blackston Works, Paisley.
352. Walker, David, Ellismuir and Calderbank Colliery, Baillieston.

353. Walker, James P., Dalmellington Iron Works, Ayrshire.
354. Walker, Robert, Tannochside, Uddingston.
355. Walker, William H., 3 Kerseland Street, Hillhead, Glasgow.
356. Walker, William, Rigside Colliery, Douglas.
357. Walton, J. Coulthard, So. Benwell Colliery, Newcastle-on-Tyne.
358. Wardlaw, John, Garriongill Colliery, Wishaw.
359. Wardrop, John, Woodside Colliery, Carluke.
360. Watson, John, Earnock, Hamilton.
361. Watson, Thomas, jun., Craignethan Colliery, Lanark.
362. Webster, David, Burdie House Lime Works, Edinburgh.
363. Weir, Alexander, Common Cottage, Auchinleck.
364. Weir, William, Caldercrooks, Airdrie.
365. Whitelaw, Thomas, Dalziel Colliery, Motherwell.
366. Williams, T. E., Camp Colliery, Motherwell.
367. Williamson, James, M'Lean Land, Dunbeath Road, Coatbridge.
368. Wilson, Andrew, Cropstone Cottage, Motherwell.
369. Wilson, Andrew M., Glorat, Milton of Campsie.
370. Wilson, J., Eastplean Colliery, Bannockburn.
371. Wilson, James, Woodend Colliery, Armadale, Bathgate.
372. Wilson, John, Alderston, Mid-Calder.
373. Wilson, John, Dechmont Lodge, Bothwell.
374. Wilson, Robert, Longrigg Colliery, Slamannan.
375. Wilson, Robert, Salsburgh, Holytown.
376. Wilson, William, Auchinraith Colliery, High Blantyre.
377. Wilson, William, Dykehead Colliery, Larkhall.
378. Wilson, William, 40 Holygate, Broxburn.
379. Wingate, David, Flemington Coal Co. (Limited), Cambuslang.
380. Wood, James, 40 St. Enoch Square, Glasgow.
381. Wotherspoon, James.
382. Wyllie, James, Townhill Colliery, Dunfermline.
383. Wyper, James, Mauldslie Colliery, Carluke.

384. Yates, Andrew, Bellfield Colliery, Hurlford.
385. Young, John, Baljaffray Colliery, New Kilpatrick.
386. Young, Robert, Thankerton Colliery, Holytown.
387. Young, Robert, 37 West George Street, Glasgow.

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